

RICE UNIVERSITY

**Multiformity:  
Toward a Multiparamater Effectiveness**

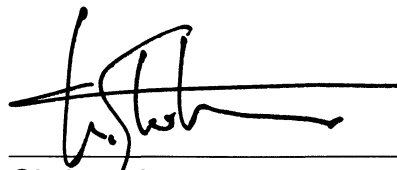
by

**Matthew A. Taylor**

A THESIS SUBMITTED  
IN PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE DEGREE

**Master's of Architecture**

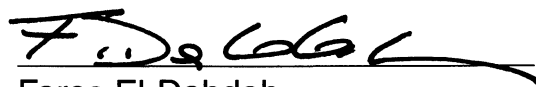
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## ABSTRACT

# **Multiformity: Toward a Multiparamater Effectiveness**

By

Matthew A. Taylor

This thesis produces new strategies for forming aggregations of units based on environmental factors. This is achieved by redefining the relationship between the public and private realms based on environmental performance and programming the formal performance; performance is defined as the dynamics between differentiated parts and their collective behavior. While typical strategies based on redistributing the unit, and recent architectural explorations in environmental performance, focus on single variable optimization; I'm interested in using multiples within environmental, programmatic and formal elements, to produce differentiation rather than optimization

## ACKNOWLEDGMENTS

To my thesis director, Christopher Hight, for his intelligence, direction and patience.

To the professors at Rice University, for helping me find what's most important within the discipline of architecture.

To my family, for believing in me and allowing me to take on challenging undertakings and ultimately supporting me through those undertakings.

To my classmates for their continuous support and for reminding me what's important during the roughest times.

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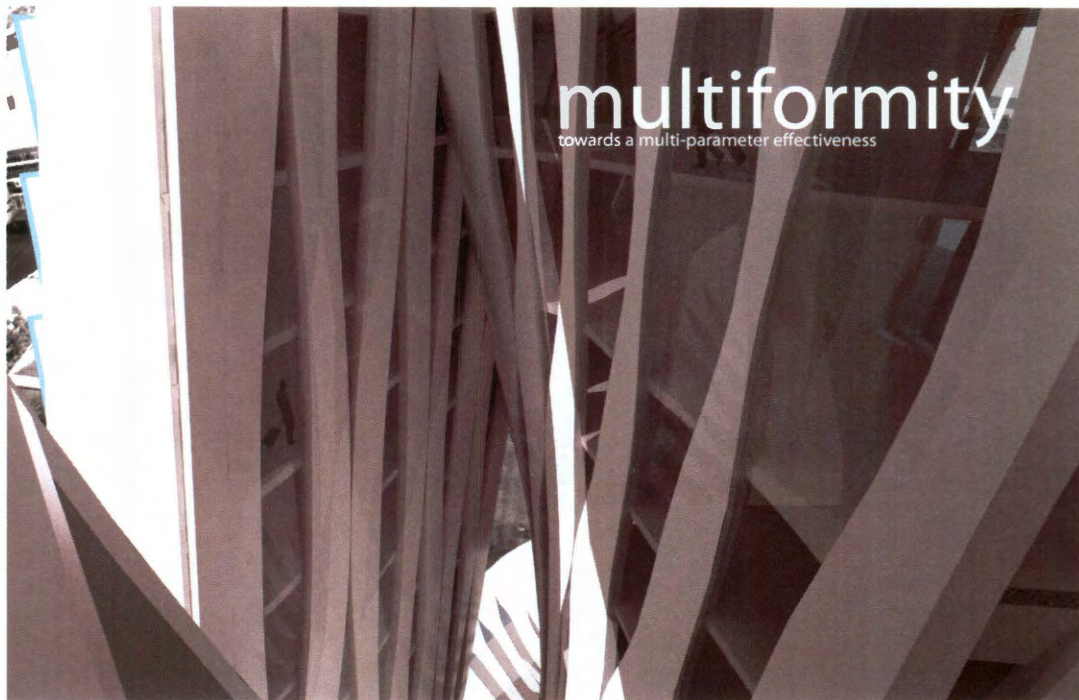


Figure 1.1

## Chapter 1 - Introduction

### 1.1 - Project Description

The term Multiformity, is a term that I use within the discipline to describe the shift from the typical - single variable optimization - to a multi-parameter effectiveness that uses many forms or shapes to produce greater effects not just between public and private spaces, but also environmental effects. With the continuous growth of our cities and the growing concern over global climate, we are forever evolving away from traditional trends to more sophisticated and environmentally responsive architecture. This thesis investigates how multiformity - 'defined as having many forms or shapes' - can advance these evolving trends through a design project consisting of a hotel and conference center in downtown Houston.

## 1.2 - The mega hotel typology as an opportunistic program

The mega hotel typology provides for an opportunistic program for this thesis to deploy these new strategies of aggregations. The unique aspects that make up the mega hotel can be seen in the Bonaventure hotel by John C. Portman which includes:

1 - Repetitive units



2 - A Complex and diverse program



3 - And an atrium space that operates in-between the two.  
**It is this in-between space that has become the focus of the thesis.**



Figure 1.2



### 1.3 - Program diagram

The diverse type and scale of the typical mega hotel program makes the building operate like a condensed city. This thesis seeks out the potential environmental effects that this in-between space can produce on the condensed city; Such that different climatic condition are produced through the formal configurations of the 'in-between' space and allowing program to breakdown according to these climatic conditions.

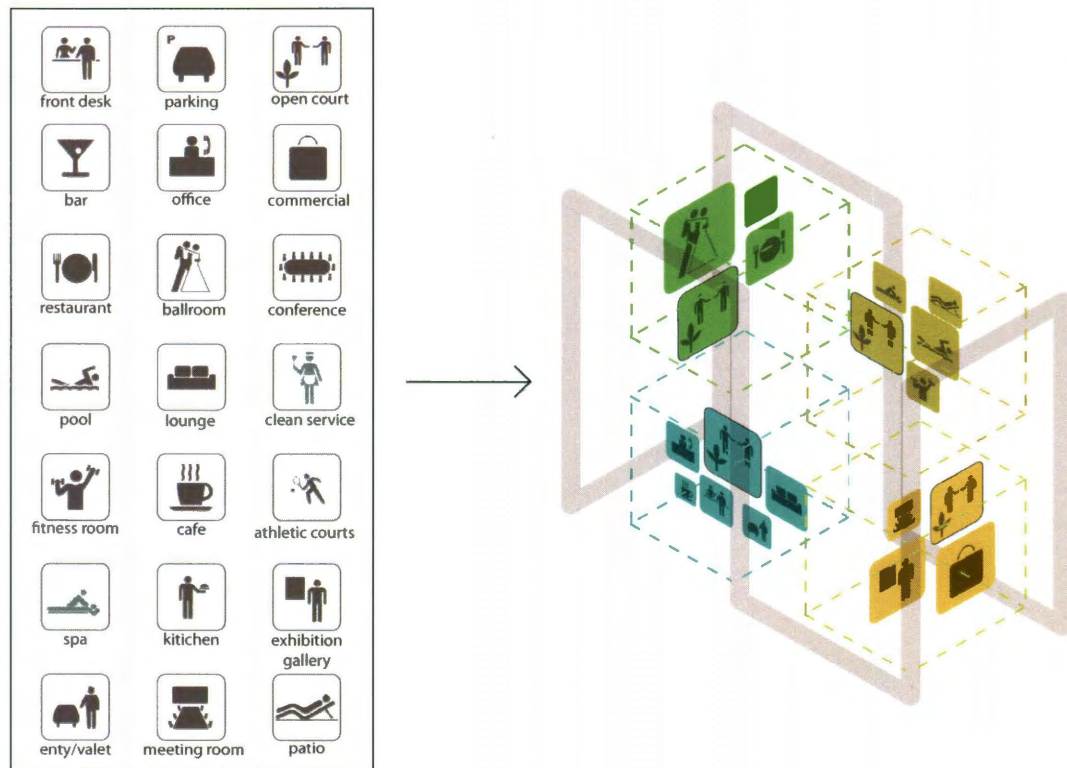


Figure 1.3

### 1.4 - The site

The site is located in the convention district of downtown Houston. In an effort to make Houston a top convention destination, the city has plans to add another convention center Hotel. The site, which mirrors the Hilton Americas across discovery Green Park, lies adjacent to the convention center. In this map, we can also identify the close proximity of multiple cultural destinations which establishes the hotel not only as a condensed city, but also as an extension of this urban fabric.

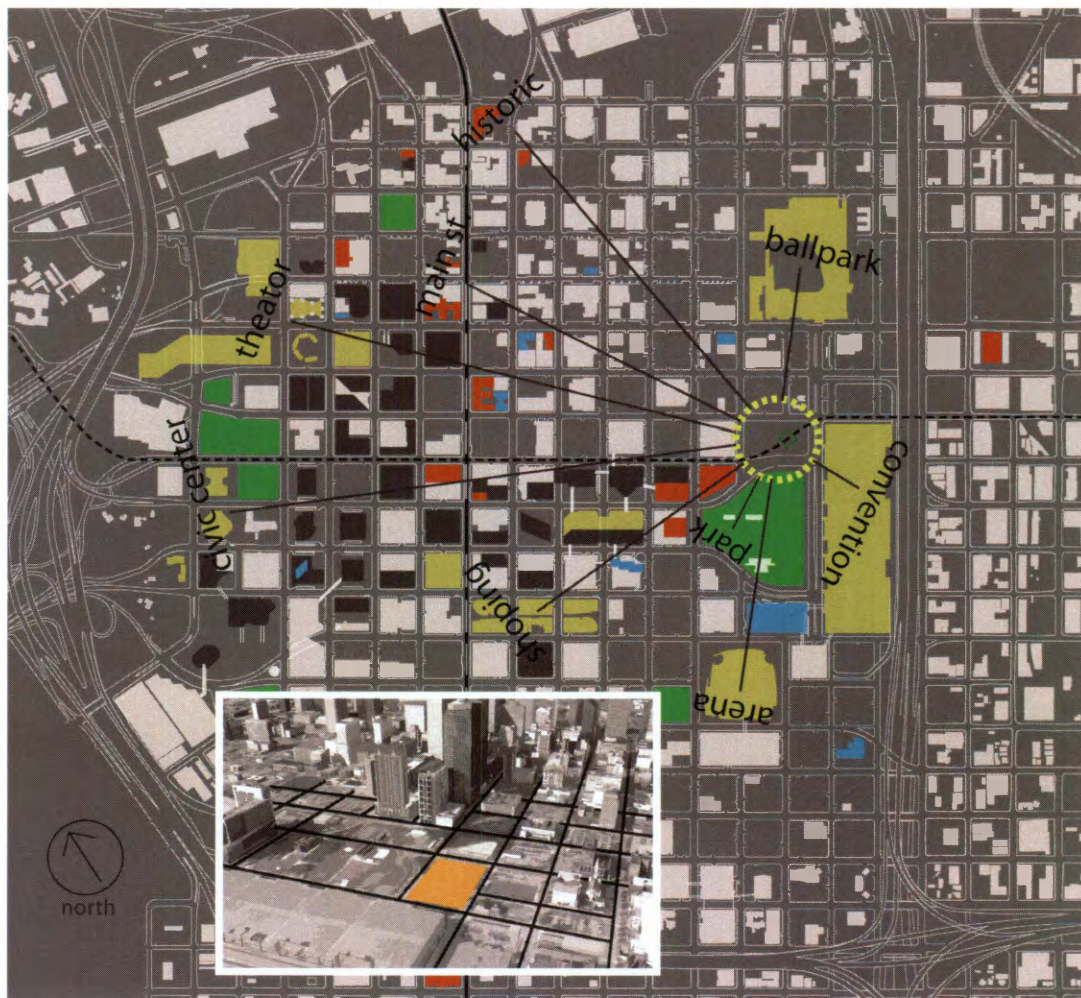


Figure 1.4



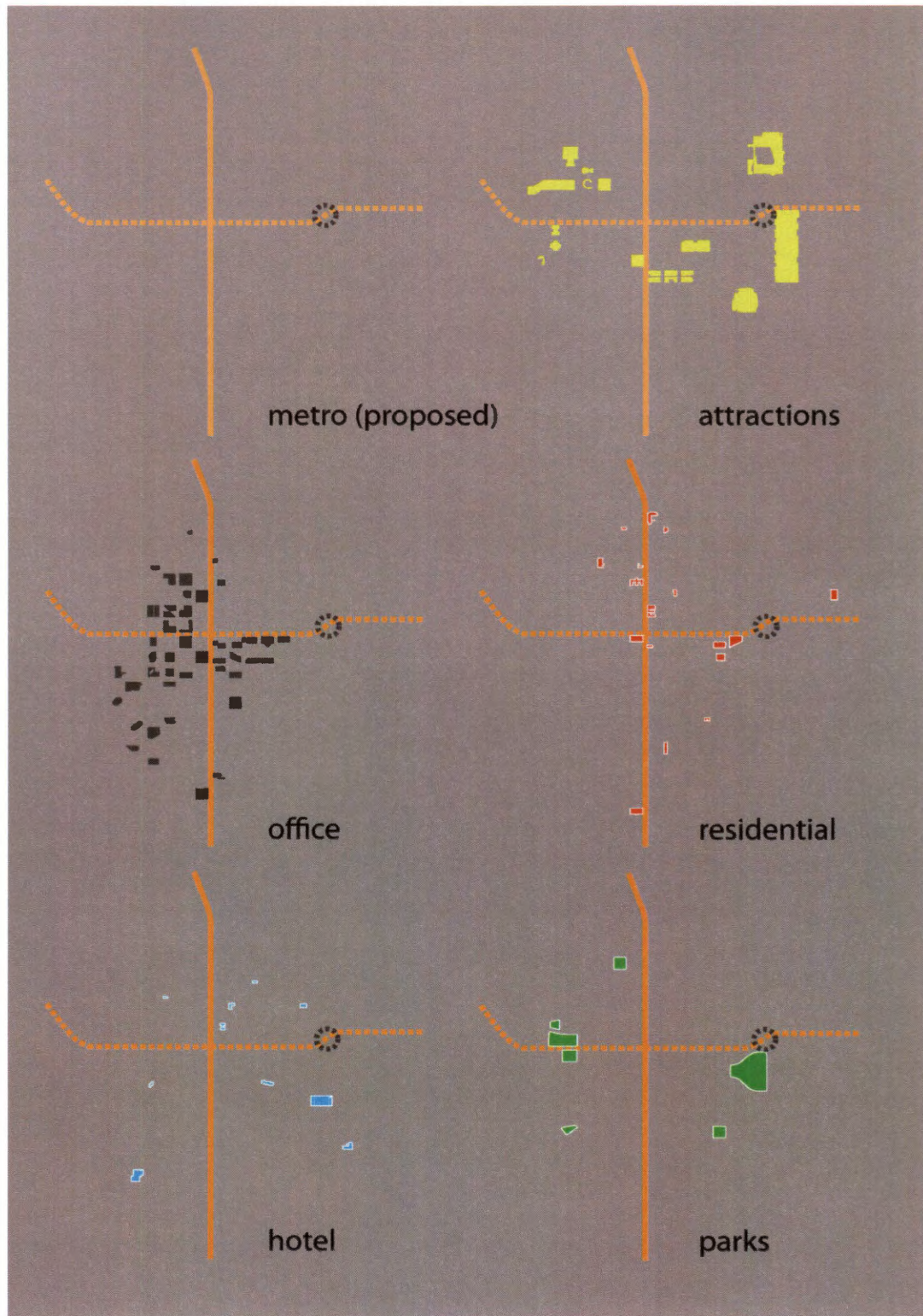


Figure 1.4



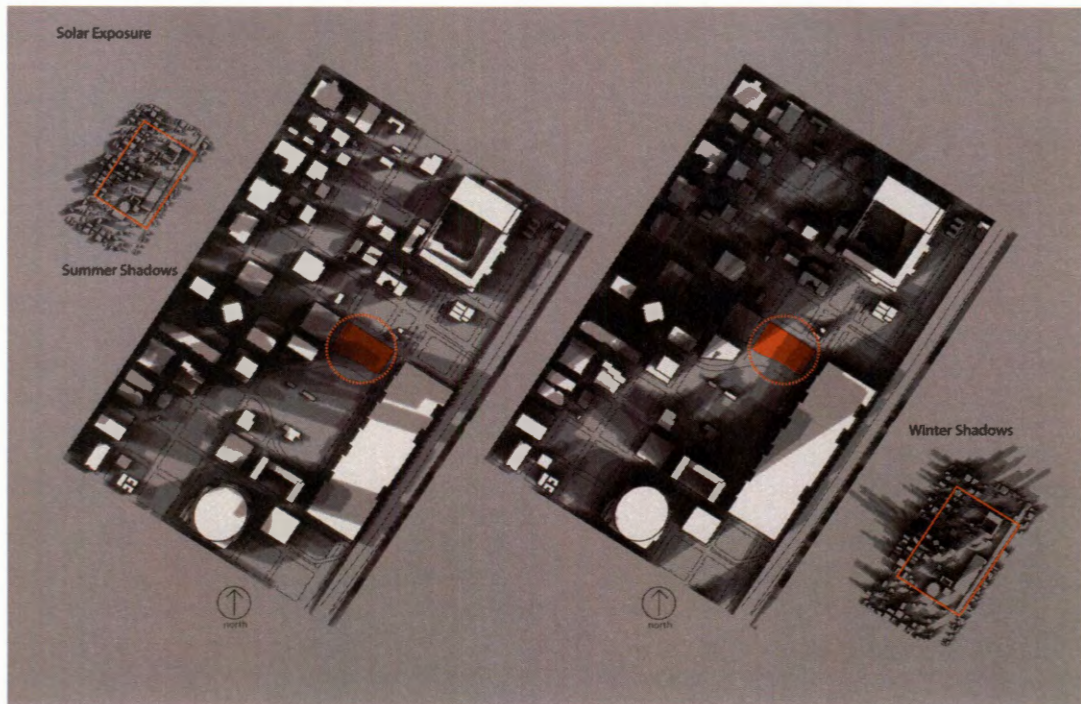


Figure 1.5

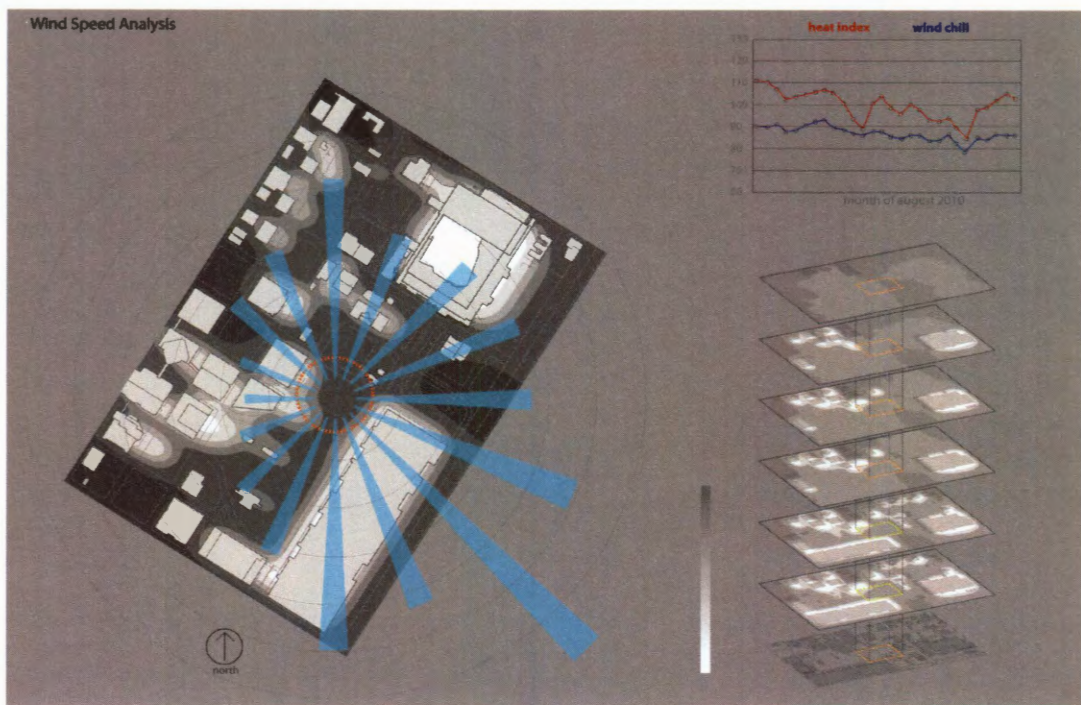


Figure 1.6



The first of these forces is sun exposure. Houston is known for its hot climate and due to the sites openness to the south; I have identified certain vectors based on sun location to be incorporated into the design (figure 1.5). The second environmental force I've identified is wind. Historically, wind was used to cool buildings, but with our advanced means of conditioning space, wind rarely becomes a consideration (figure 1.6). And zooming in on the site, it's clear that each side of the site is diverse. To the west is the convention center; to the east is high-rise residential and the rest of downtown. To the north are undeveloped lots and to the south is the discovery green park

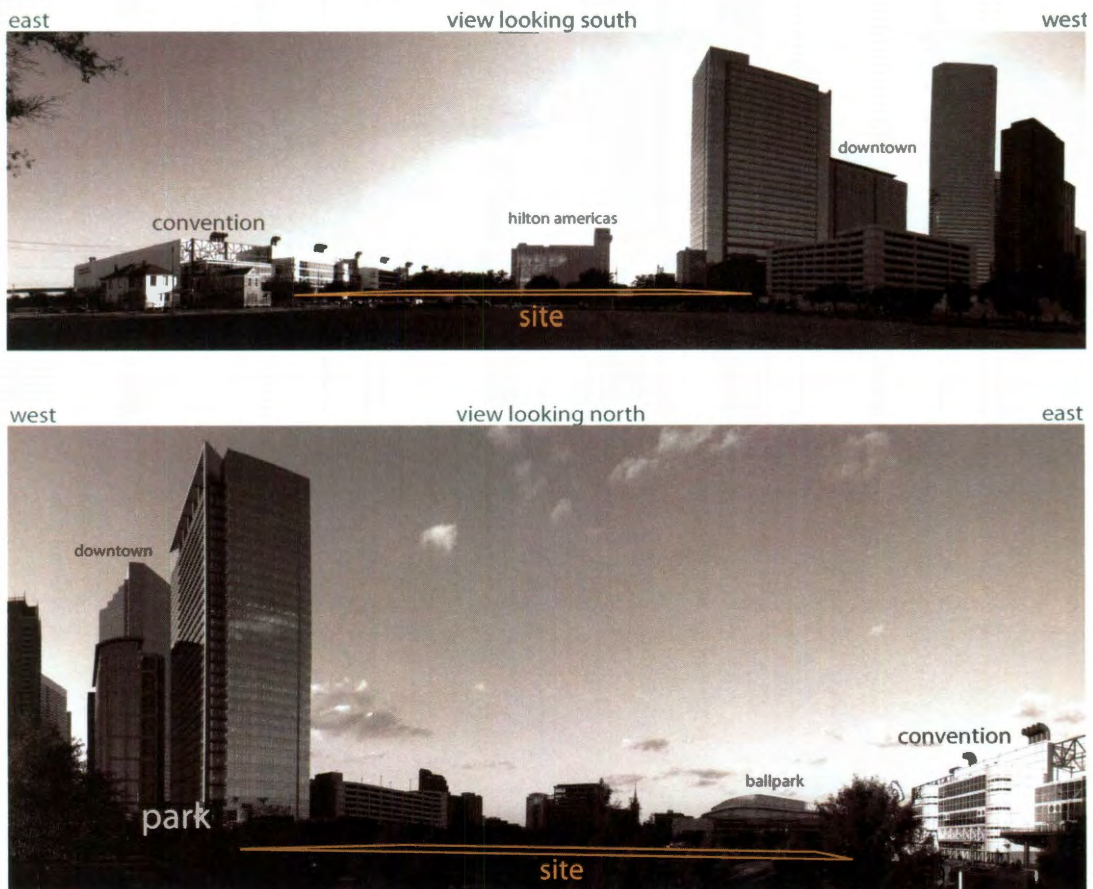


Figure 1.7



## Chapter 2 - Design Approach

### 2.1 - Unite d'habitation

The design approach first pulls reference from the Unite d'habitation by Le Corbusier, because it clearly expresses the relationship between part and whole such that it is made up of an aggregation of units that interlock into a larger whole. The collective space on the street and roof operate as very distinct domains (figure 2.1). The relationship between the individual units and the collective space establishes the Unite as a completion in the sense that it has a clear whole. And it also operates like an entire city that gets shrunk inside a building and develops its own degree of autonomy.

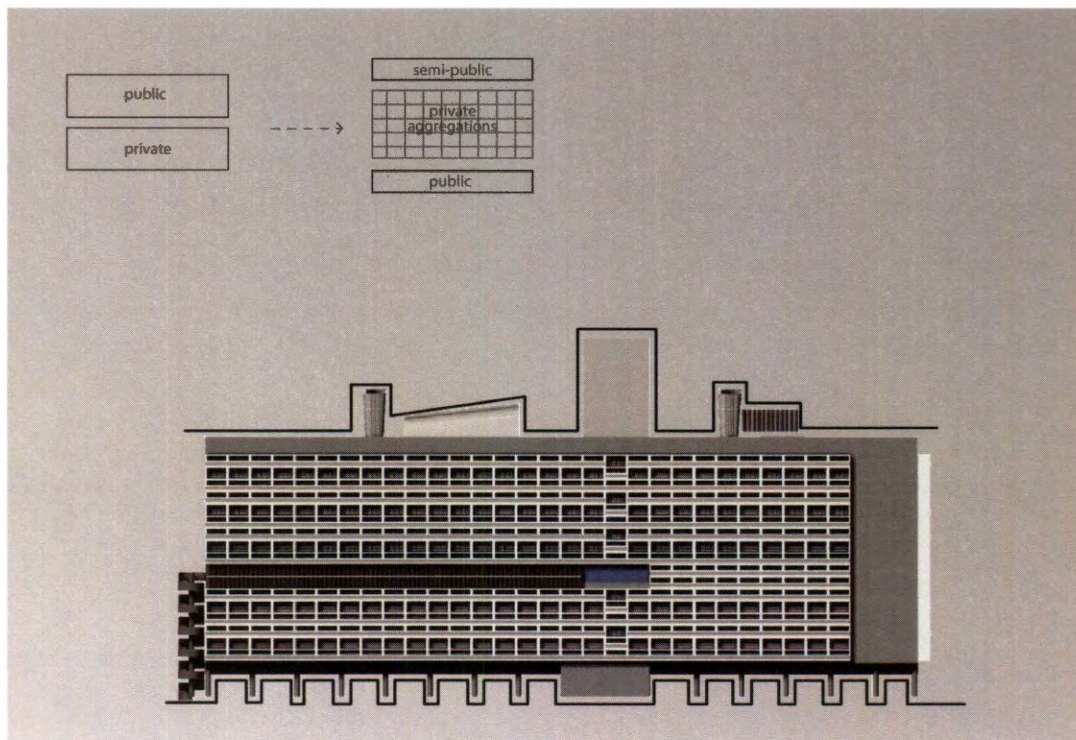
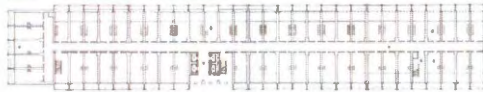


Figure 2.1

## 2.2 - Reframing

Expanding upon the unite, this thesis reworks the framework from a single homogenous field to multiple frameworks that are informed by environmental and programmatic relationships - forming differentiated collective space in a vertical configuration.

Plan - Unite d'Habitation



Homogeneous Grid Extracted



Differentiation based on external parameter

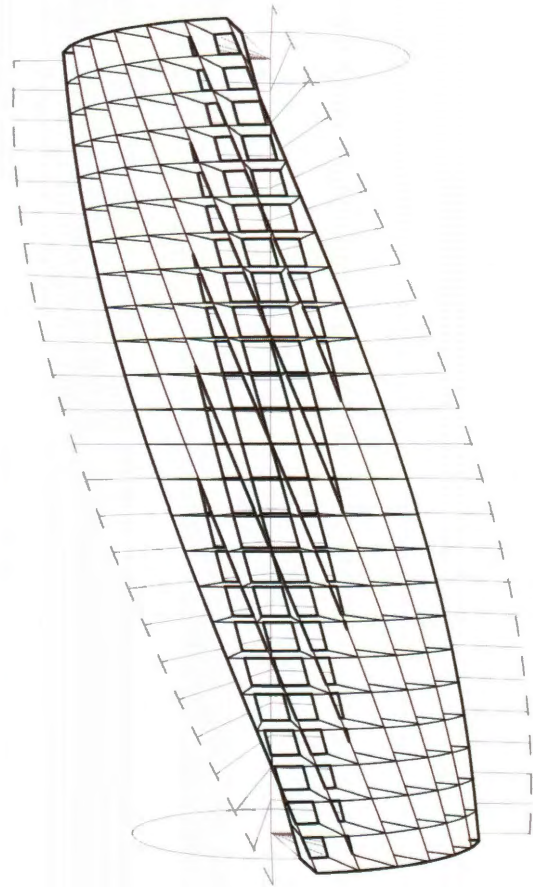
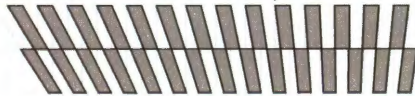


Figure 2.2



### 2.3 - Envelope Typologies

To deploy this reframing strategy, the thesis reconfigures the typical mega hotel typology from repetitive units stacked atop a podium to two vertical elements, thus, establishing a vertical relationship between two different envelope typologies. One envelope typology is what alejandro zera-polo describes as a flat vertical envelope, this envelope operates as the aggregation of units. The other envelope typology is what zera-polo describes as a vertical envelope which operates as a continuous public core.

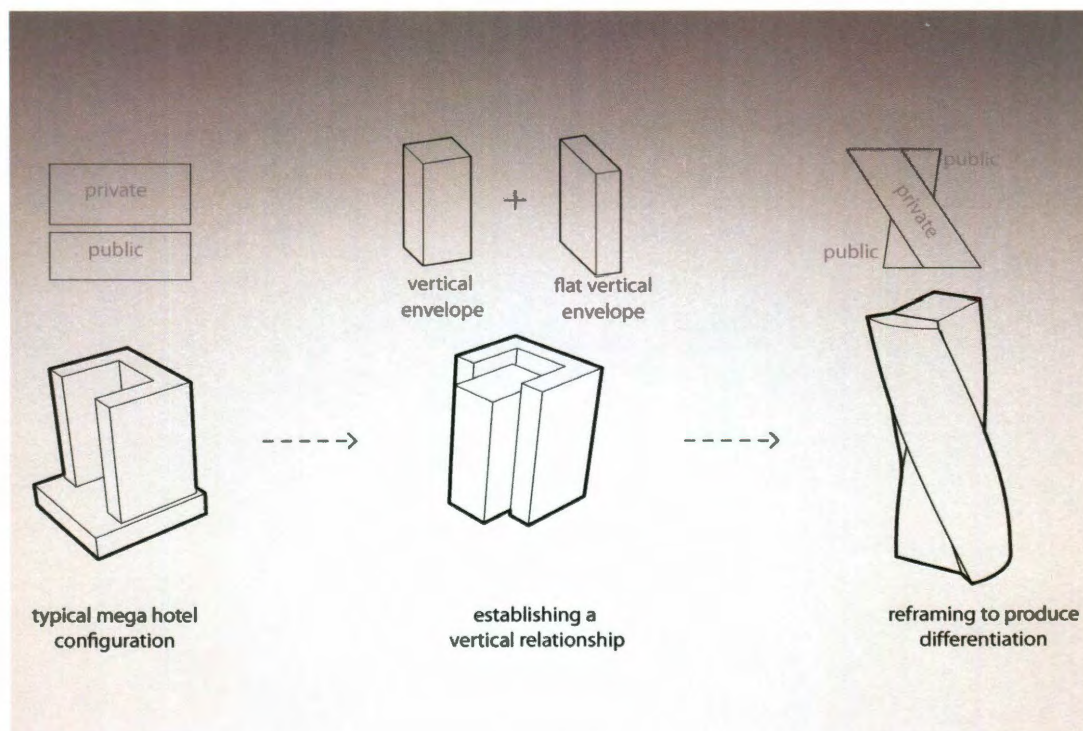


Figure 2.3

## 2.4 - Final form and the open air plenum

Working with the two envelope typologies, the design approach uses a rotation strategy to create differentiated vertical public spaces. This rotation strategy is copied through six flat vertical envelopes typologies, producing multiple frameworks around two inner cores (figures 2.3 and 2.4). Seen here together this copy rotation strategy between the two different envelopes produce a unique third condition in-between (figure 2.6).



Figure 2.3



Figure 2.4

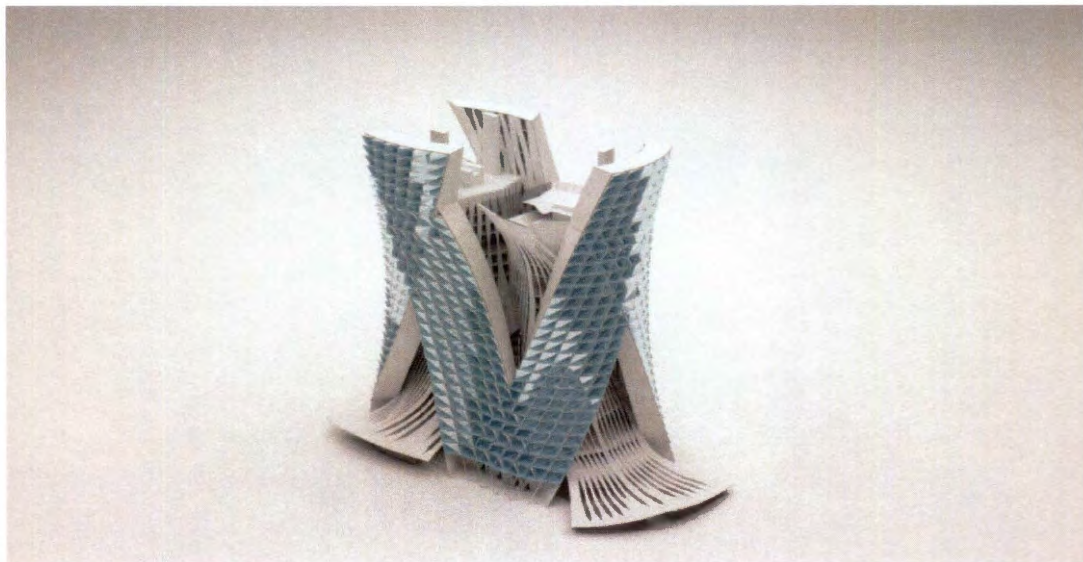


Figure 2.5



The third condition rendered in figure 2.6 creates what I call an open air plenum. This open air plenum Functions not only as a void between the aggregation of units and the continuous public core but can also function as a modulator of environmental conditions.

This form was established through formal research based primarily on environmental conditions and the social interactions that engage with those conditions. Rather than optimizing building performance by protecting the interiors from the exteriors in the most 'efficient form', this form promotes an engaging relationship between the inhabitants and the exterior environment.

The following chapters with describe the process in achieving the final form through research of 'emergent design' and formal investigations.



Figure 2.6

## Chapter 3 - Research:

### 3.1- Defining emergence within design

Emergent design begins with the recognition of buildings not as singular and fixed bodies but as complex energy and material systems that has a life span and exist as an iteration of a long series that proceeds by evolutionary development and towards an intelligent ecosystem. The book “Emergence Morphogenetic Design Strategies” lists the strategies for emergent design (Hensel):

- 1) Social interactions become more complex and more intense.
- 2) Has to be made better by spacial and infrastructural design that maximizes **qualitative** and **quantitative** factors.
- 3) Emergence provides life cycles and ways they interact with each other.

Emergence is then defines as: Properties of a system that cannot be deduced from its components - something more than the sum of its parts. This calls for a more mathematical architecture that liberates tectonics from orthogonal geometries and demands more precision between form and computer drawn fabrication. This logic of emergence demands that we recognize that buildings have life spans and have to maintain complex energy and material systems (Hensel).

- 1) Disassembled and recycled
- 2) Rethinking of environmental performance
- 3) Extend beyond individual building to its environment

### 3.2 - “Form Finding”

Form and force are correlated, in that the form of a structure can be determined as the state in which the forces acting in and on it are at equilibrium, this is achieved through a feed back loop. Key points that make “Form Finding” important within architecture are (Hensel):

- 1 - Material systems as inherently dynamic
- 2 - Shifting from static and discrete to motile material arrangements that respond to the environment
- 3 - dynamic relation between material arrangements and human behavior.
- 4 - Form Finding goes beyond design and construction towards a process of adaptation of the built environment

Architecture and design was critically dependant on Geometry, but that a complete geometric tradition of the understanding of descriptive and construct geometry was being lost through lack of bland planar and orthogonal minimalism or, misuse by being excessively indulged at the hyper fringes of design. Simulations can now inexpensively incorporate the advanced physics of nonlinear behavior to explore the dynamic changes that structures and materials undergo in response to changing conditions (Hensel).

Cities are complex systems. The flow of vehicles and people within a city represents the emergent behavior of such a system, produced by the large numbers of decisions of individuals, and their interactions with each other and their transportation systems. Complex systems are non-linear and sensitive to initial conditions such that small changes can result in turbulent behavior at the global scale (Hensel).

### **3.3 - Arguing for Differentiation rather than homogenization**

Architectural tradition is fundamentally characterized by substantial structures and building typologies linking tectonics with function and representation. This characteristic links material constituents that frame space to program or social formations. As a result, interiors are largely homogenized and homogenizing (Hensel). This comes from the modernist open plan and industry standards.

Instead, this thesis argues for an architecture that promotes differentiation of environmental conditions. To produce an architecture that links performance capacity of material systems with environmental modulation and resulting provisions and opportunities for inhabitation, based on the argument that homogenized interiors cannot satisfy the multiple needs of inhabitants.



## Chapter 4 - Formal Research:

### The development of the open air plenum

#### 4.1 - A synergetic relationship between form and function

I argue that typical projects within this discourse tend to take two different approaches (See case studies and diagrams on page 45). One that uses environmental forces such as thermal, structural, and wind to determine material organization, but the subject and quality of space become afterthoughts. The other uses the subject, or inhabitant, to determine spacial organization but leaves the environmental forces as afterthoughts.

What I propose is a concept for design that helps re-consolidate form and function into a synergetic relation with the dynamics of natural, cultural and social environments – Thus, locating capacity in the spatial and material organization of architecture in the human subject and the environments through the dynamic interaction between these four domains.

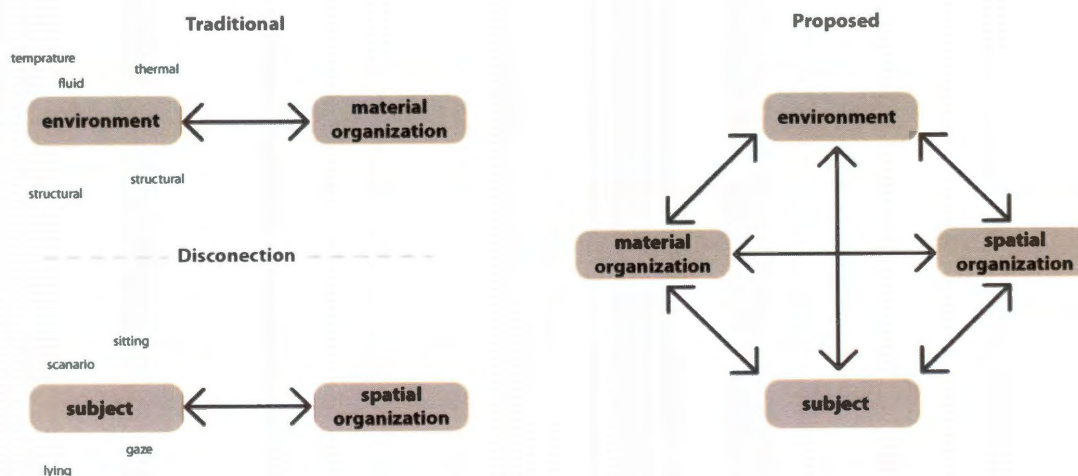


Figure 4.1

## 4.2 - Rethinking spatial division

To begin the formal investigation, I started with a traditional method of spatial division; one that subdivides spaces in an equal and rectilinear system. Then releasing the system from the 'single variable' - orthogonality to produce varied patterns of non-rectaliner spatial divisions (figure 4.2). These studies where carried out further investigating new rule parameters and degrees of random parameters (figures 4.3 and 4.4).

Next, the study was carried out using three dimensional geometries that divided a solid box through all three axes. Using computer software and scripting, the studies can be modelled digitally and changes, variations and constraints can be observed instantly (figures 4.5 and 4.6)

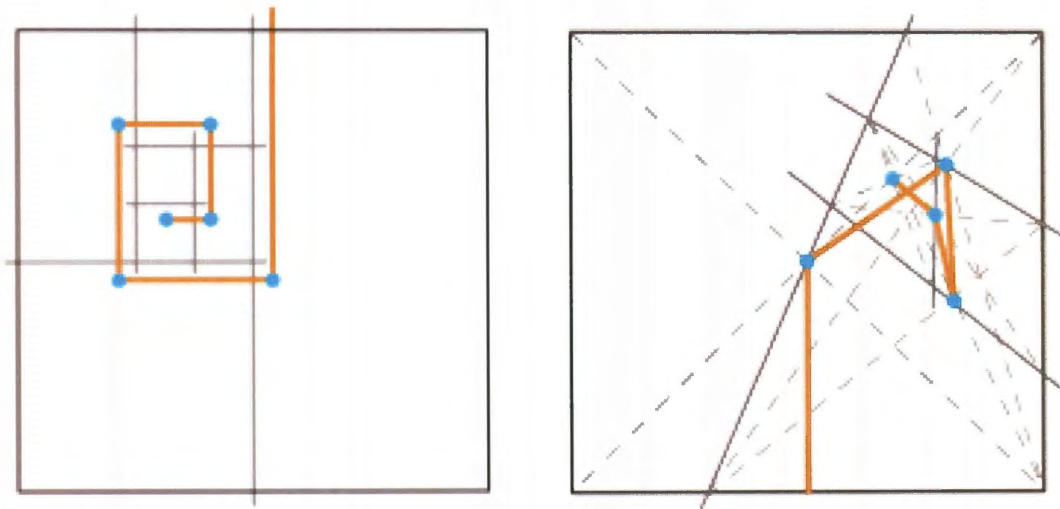


Figure 4.2

### Rule Based Parameters

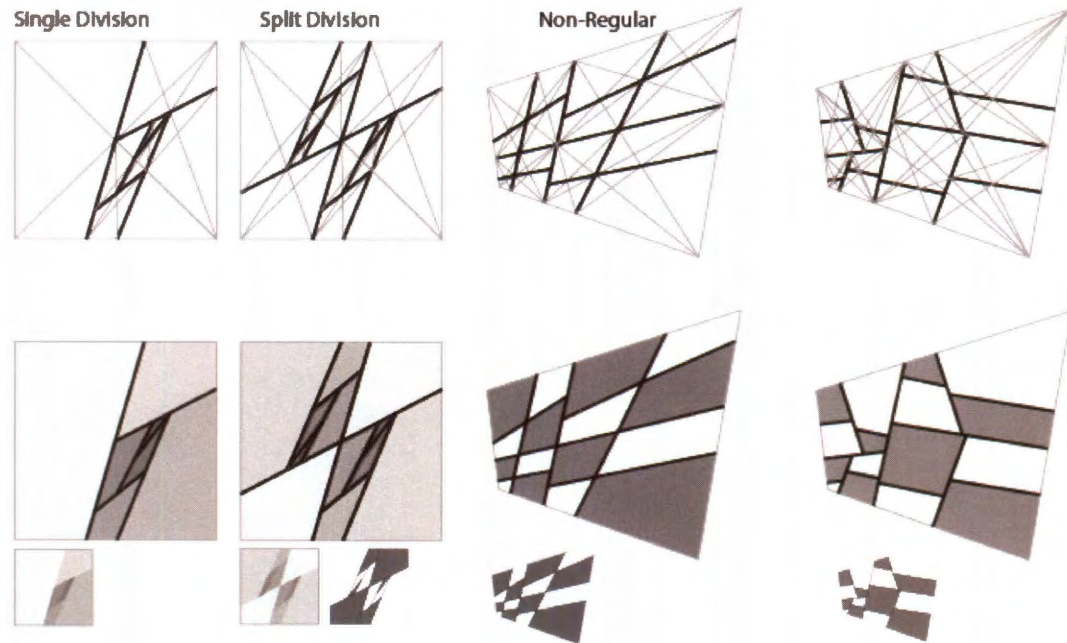


Figure 4.3

### Random Parameters

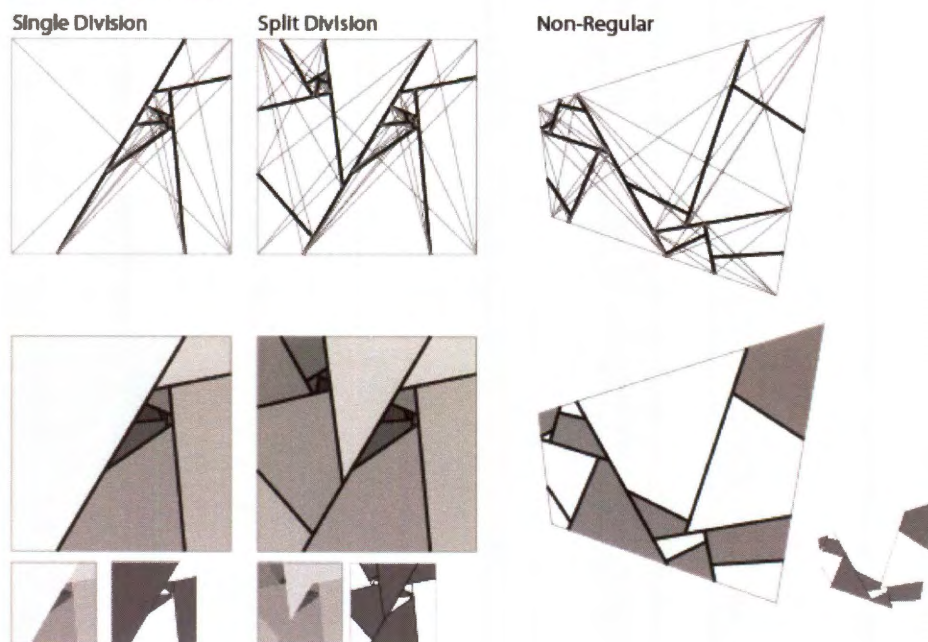


Figure 4.4



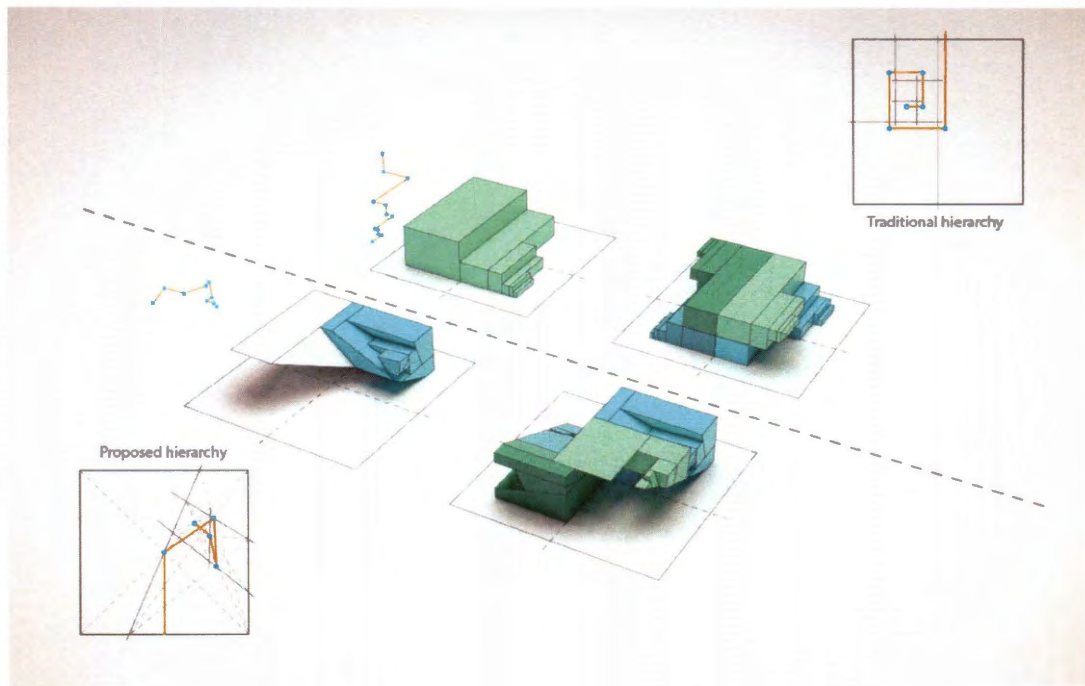


Figure 4.5

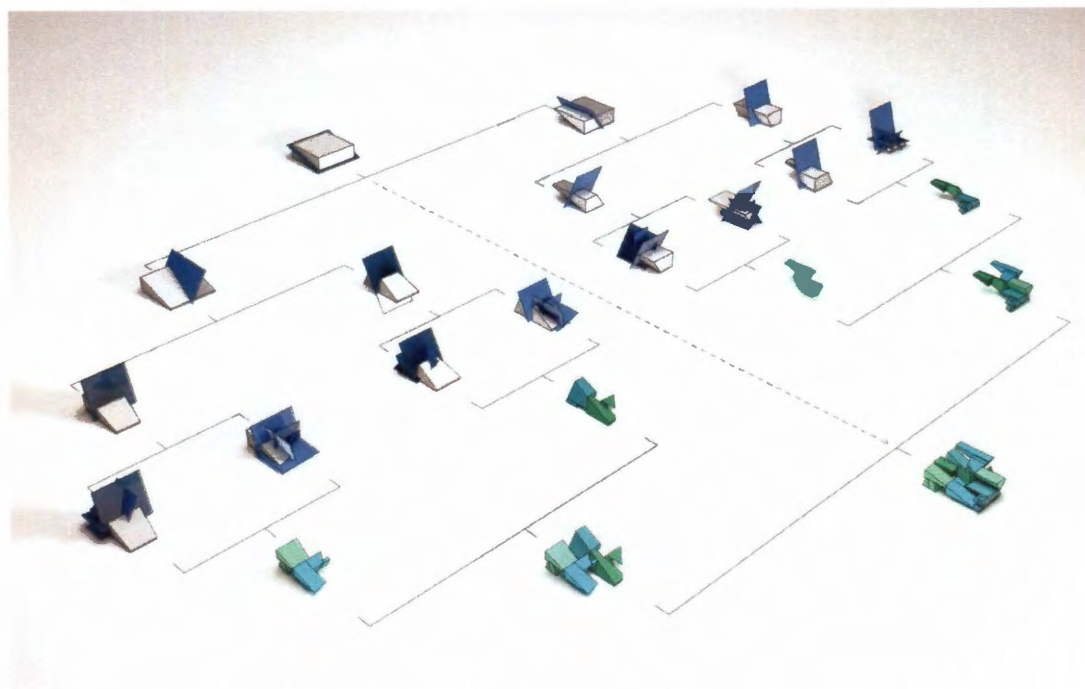


Figure 4.6

### 4.3 -Vertical Iterations

The next study used the same set of parameters as the previous study of spatial division but introduces additive iterations. The idea behind additive iterations is that one instance is created and from that instance another added to it with minor changes. This process continues until a global form emerges that encompasses something larger than the sum of the individual instances.

The additive iterations are conducted in a vertical configuration because the thesis investigates a high rise typology. These studies are good in determining how to achieve differentiation in a vertical system, something that is lacked in traditional approaches to high rise typologies.

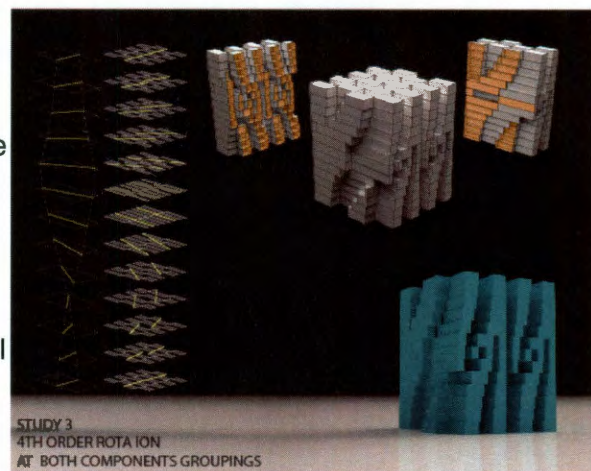
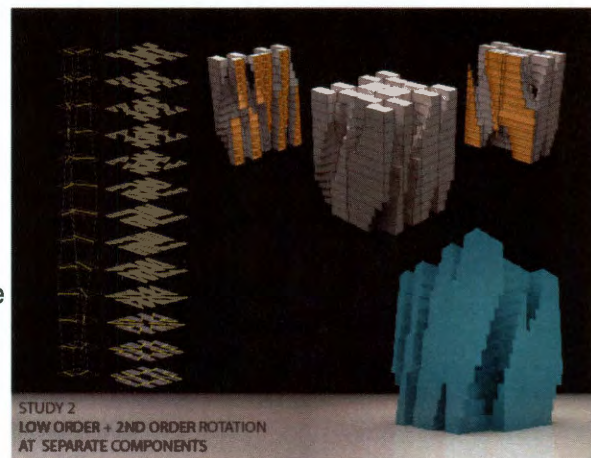
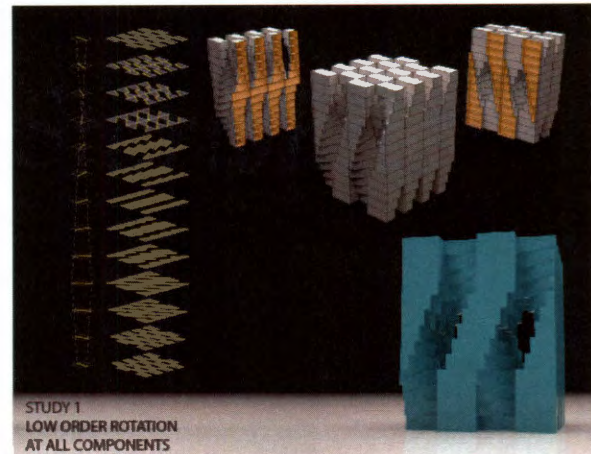


Figure 4.7



#### 4.4 - Actualizing the study models

In figure 4.8, I begin to distinguish the different elements being produce through the vertical iterations of spatial divisions. At a higher order, three groups become easily distinguishable wrapping around one another. White - becomes a continuous public core. Red - becomes the individual private units with another lower order spatial divisions between the individual units. And transparent - becomes a continuous void modulating between the two.

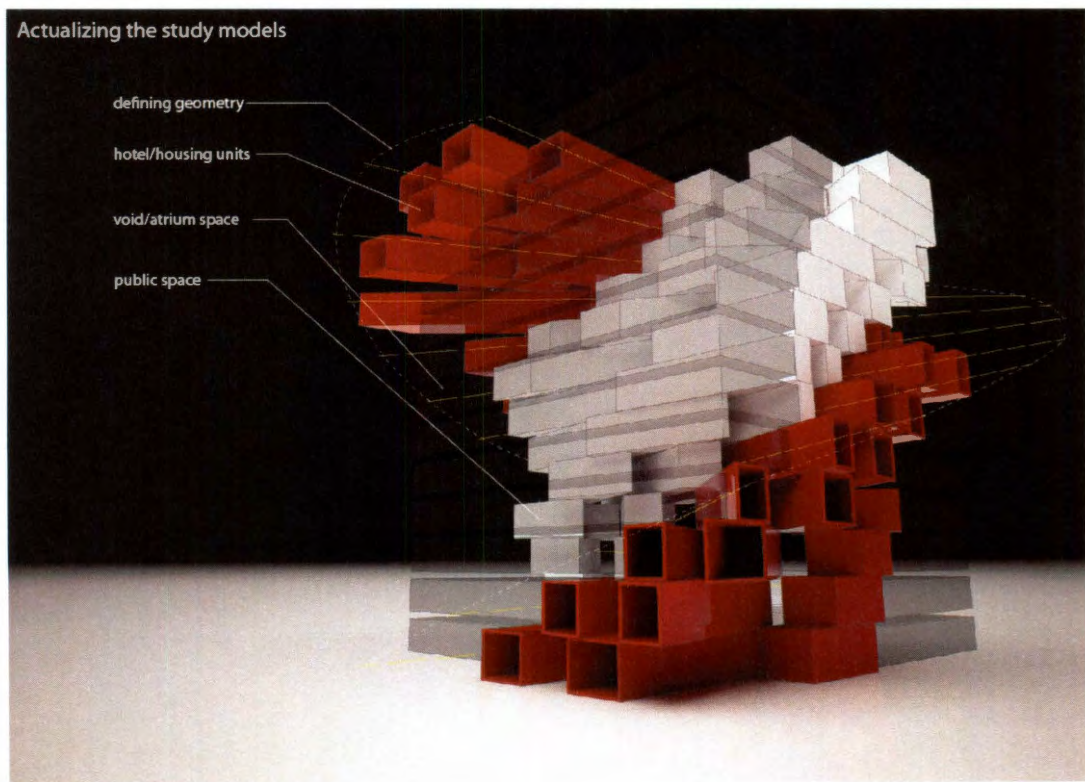


Figure 4.8



Figure 4.9

#### 4.5 - Search space

Working from the previous model and the three elements: public core, individual units and void space, multiple variations were investigated. Each variation investigates different degrees of rotational parameters and directional parameters and variables between higher and lower orders of spatial division (figure 4.10).

A final configuration was selected (figure 4.11) based on the resulting form created by the three elements. This form allows the void space to modulate between the public and private elements providing different degrees of connectivity between the public core and individual units while also creating a continuous air plenum between the two. This is further explained in the following chapter.

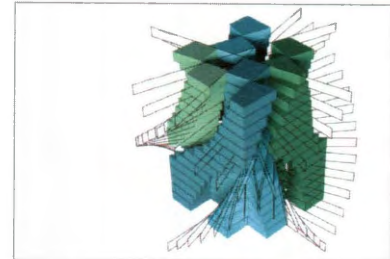
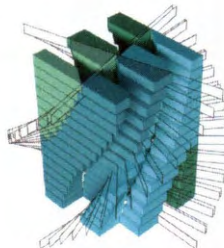
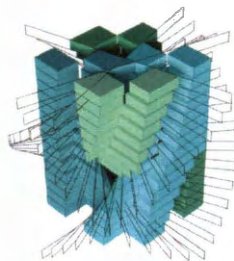
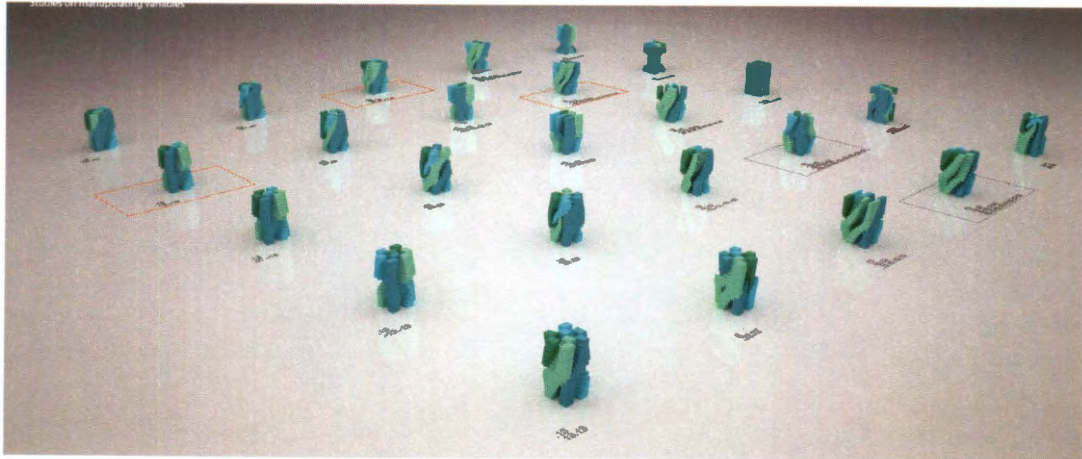


Figure 4.11



## Chapter 5 - Formal Process:

### The development of micro-climatic zones

#### 5.1 - Formal Operations

The first step shows how a rotation operation between two surfaces form an open space in-between (figure 5.1). The same operation occurs between the two envelope typologies. And this starts to create distinct zones that when analyzed through environmental trajectories – such as wind movement and solar exposure – the public core becomes exposed and protected, differentiating the zones from one another (figure 5.2).

Multiple operations are brought together to create a continuous open air plenum (figure 5.3). The thesis then investigated multiple variations produced by this geometry to identify the best configuration for the site (figure 5.4)

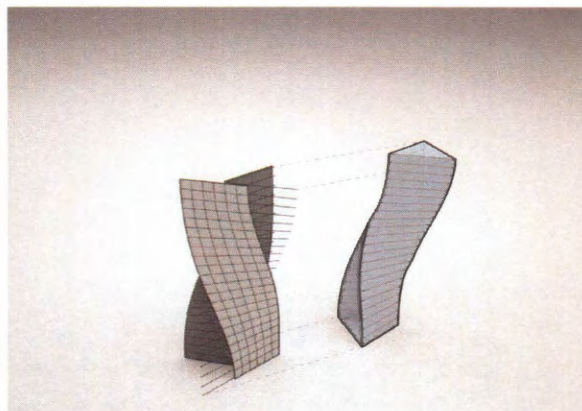


Figure 5.1

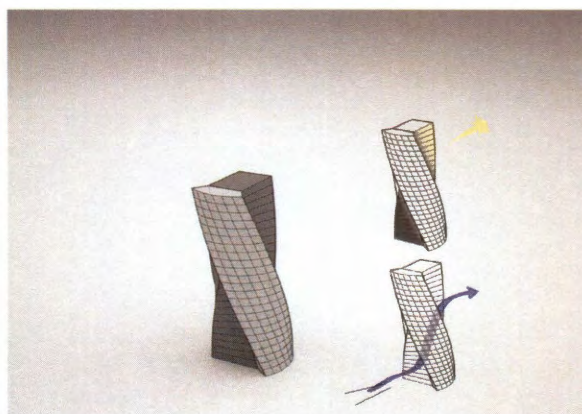


Figure 5.2

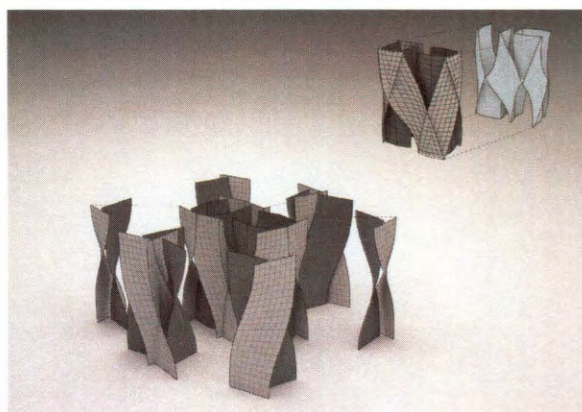


Figure 5.3



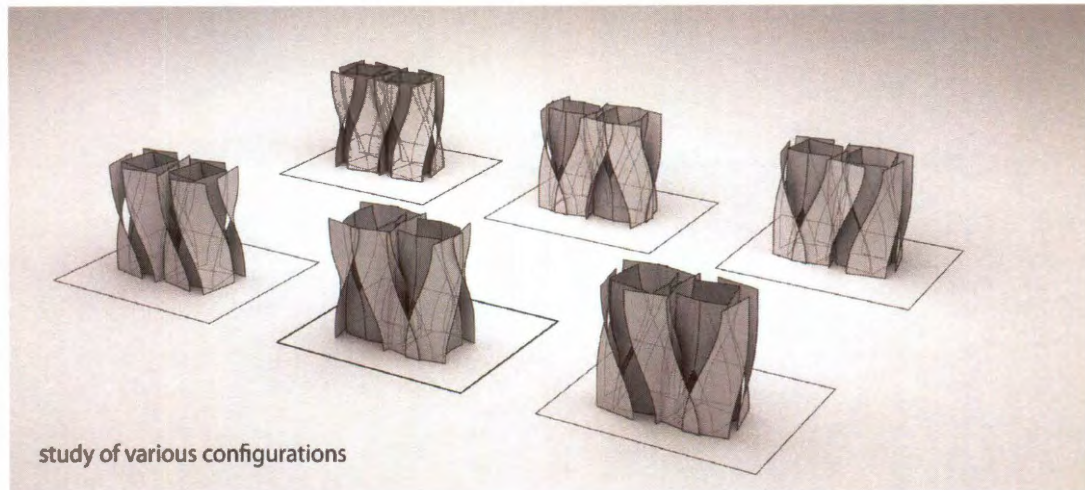


Figure 5.4

## 5.2 - Extrinsic Forces

The selected configuration (figure 5.5) is based on both environmental effects and connections to urban context. The environmental effects can be seen in figures 5.6,

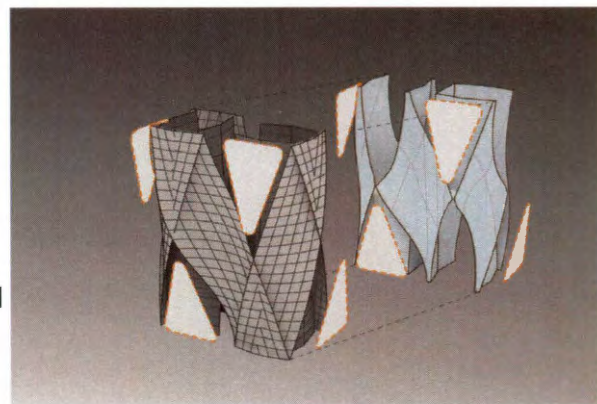


Figure 5.5

5.7, 5.8, 5.9. 4 zones are created by the separation of the aggregations of the units exposing the open air plenum and the public core to the exterior. The radiance simulation shows how each zone has different degrees of exposure to the sun identifying certain areas as hot and highly exposed and areas of cooler and shaded.

The urban context also plays a crucial role in creating different zones, such that each zone meets the urban context at 4 different locations. Two meet the ground at the park and convention center and two with overlooking views of the park and downtown Houston (figure 5.10).

### Micro-Climatic zone 1: The relaxed collective zone

This zone is directly connected to the adjacent park and contains the least amount of direct sunlight.

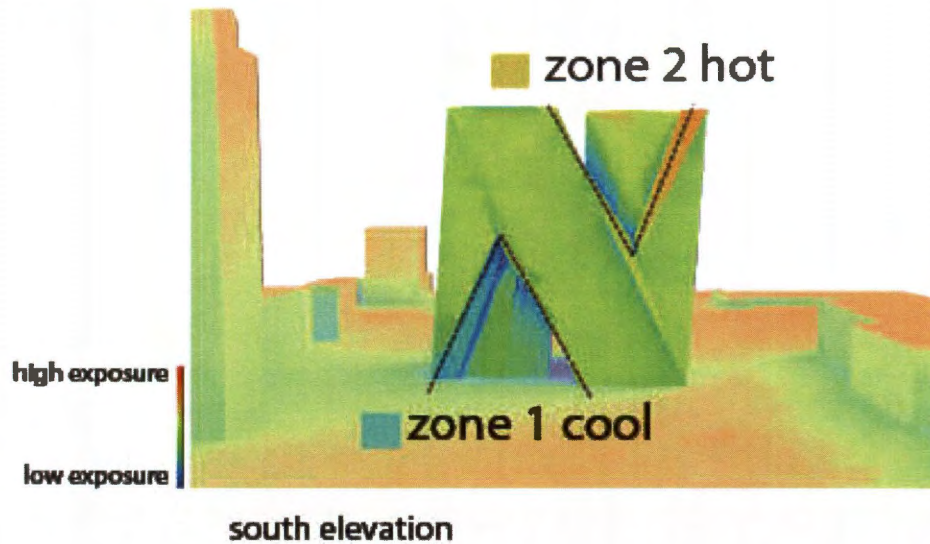


Figure 5.6

### Micro-Climatic zone 2: The healthy collective zone

This zone receives sunlight all day creating an environment for active and outdoor activities.

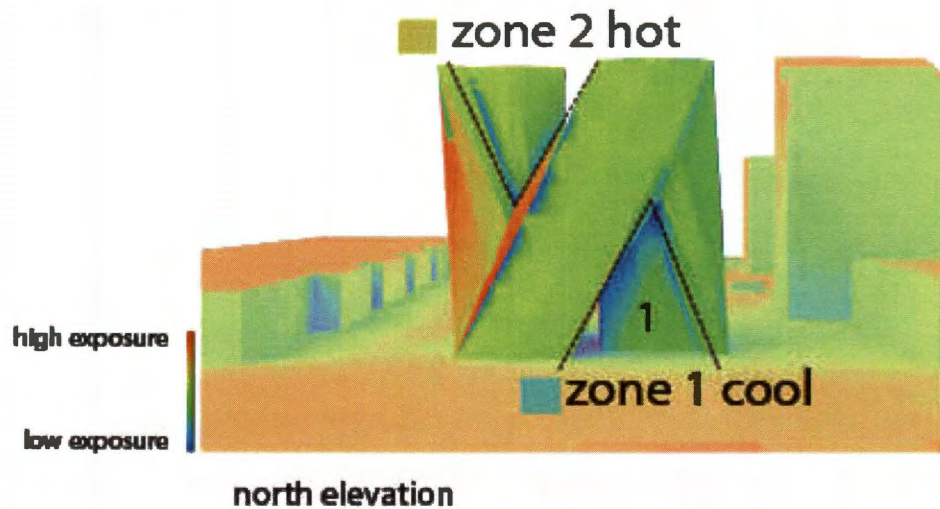


Figure 5.7



### Micro-Climatic zone 3: The civic collective zone

This zone is located off the new civic corridor and allow for direct connection to the public street



Figure 5.8

### Micro-Climatic zone 4: The entertainment collective zone

This micro- climatic zone receives late afternoon sun which is ideal for evening entertainment activities.

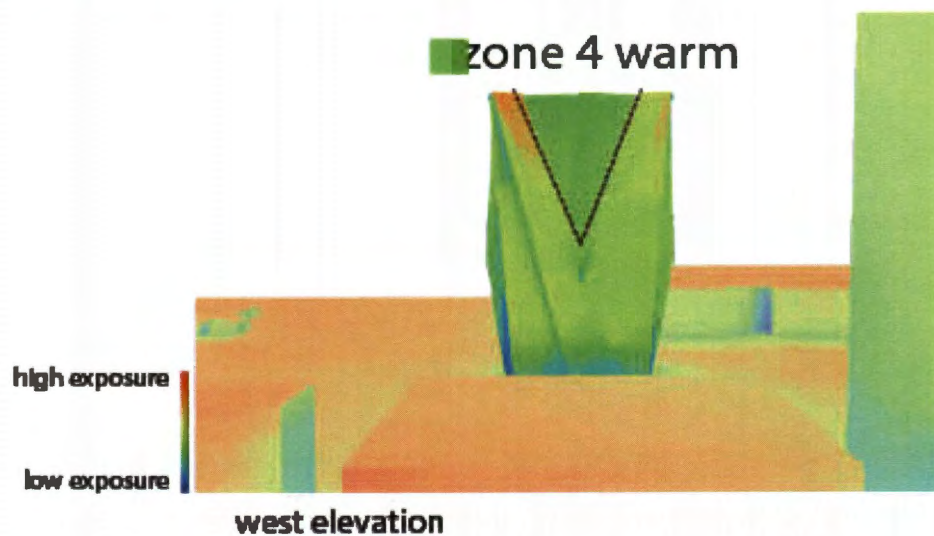


Figure 5.9

The urban context also plays a crucial role in creating different zones, such that each zone meets the urban context at 4 different locations. Two meet the ground at the park and convention center and two with overlooking views of the park and downtown Houston.

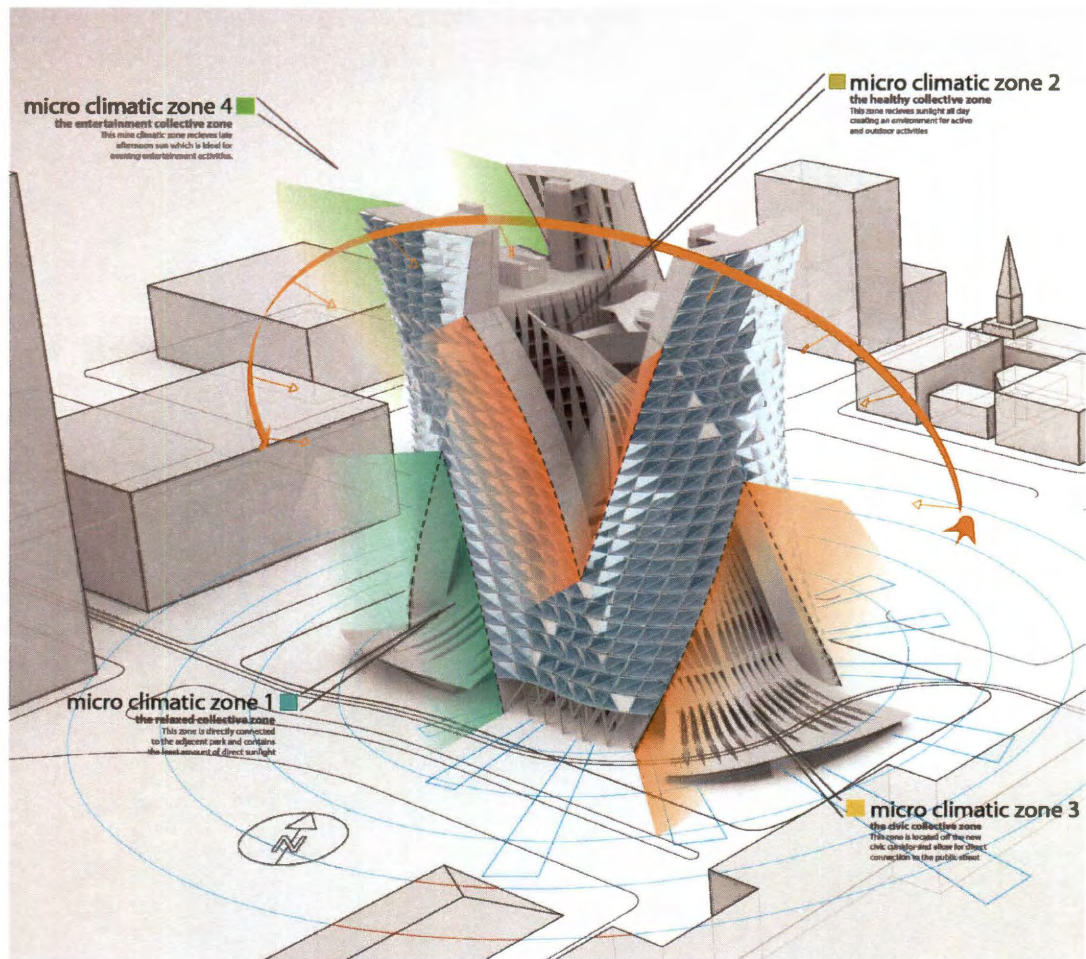


Figure 5.10



### 5.3 - Fine Tuning

The design, because of the flexible nature of the aggregations, allows the scale of the program to expand and contract reshaping the initial global mass (figure 5.11).

Again, through the flexible nature of the aggregations, I have fine tuned the global geometry to better align with prevailing winds and to heighten or reduce the degrees of exposure (figure 5.12).

The modulation which I express in figure 5.13 - a diagram that expresses the open air plenum as a solid - shows how each area of exposure faces different direction resulting in differences in exposure and how this continuous open space allow air to circulate through the building acting as a cross ventilation at the global scale

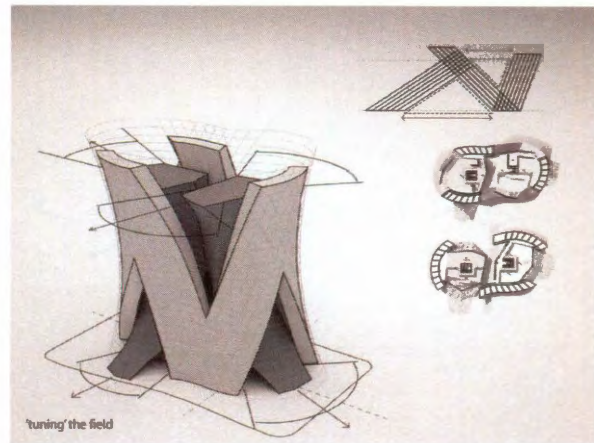


Figure 5.11

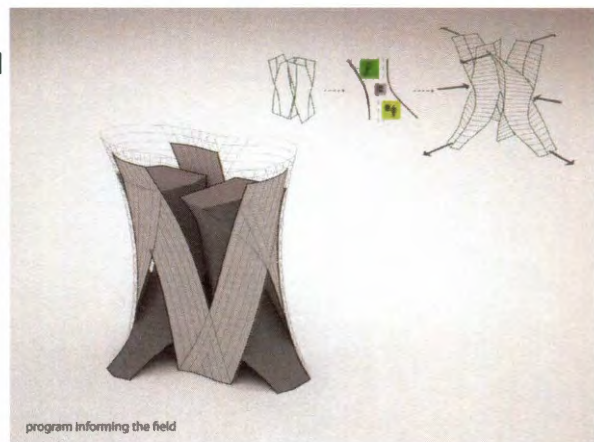


Figure 5.12

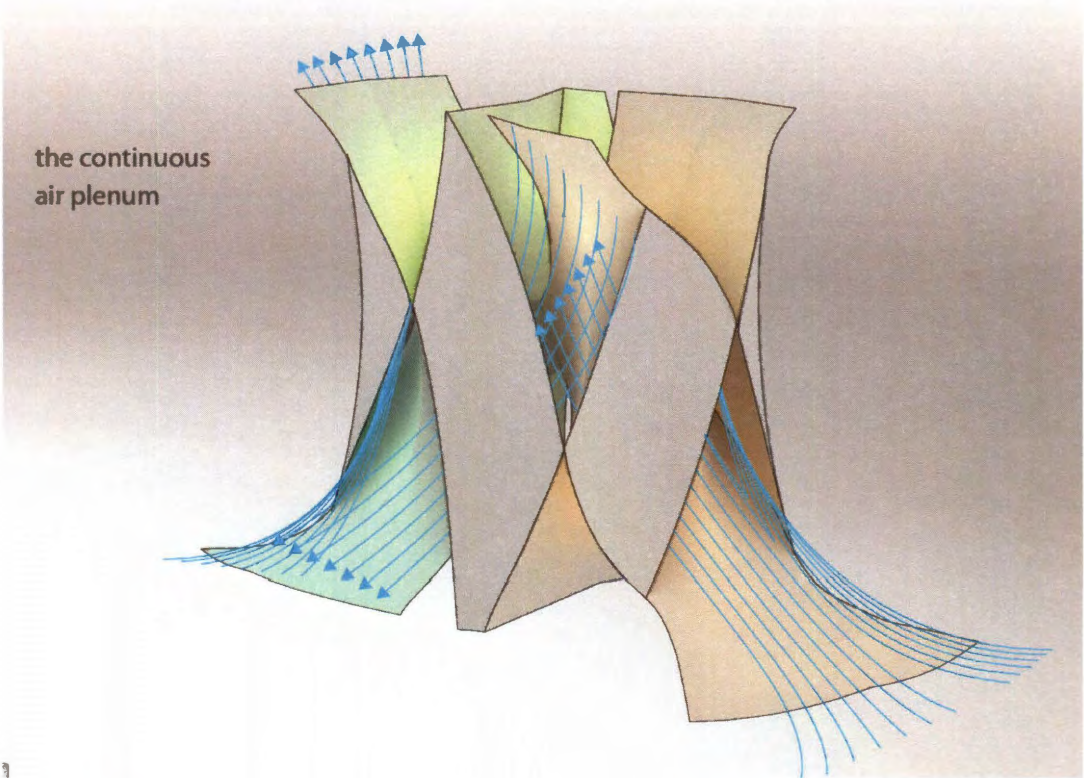


Figure 5.13

## Chapter 6 - Programmatic mapping

### 6.1 - Program matrix and fit criteria

The thesis then analyses the typical program of the mega hotel through a matrix that identifies each programmatic elements fit criteria to the micro-climate produced through the formal configuration.

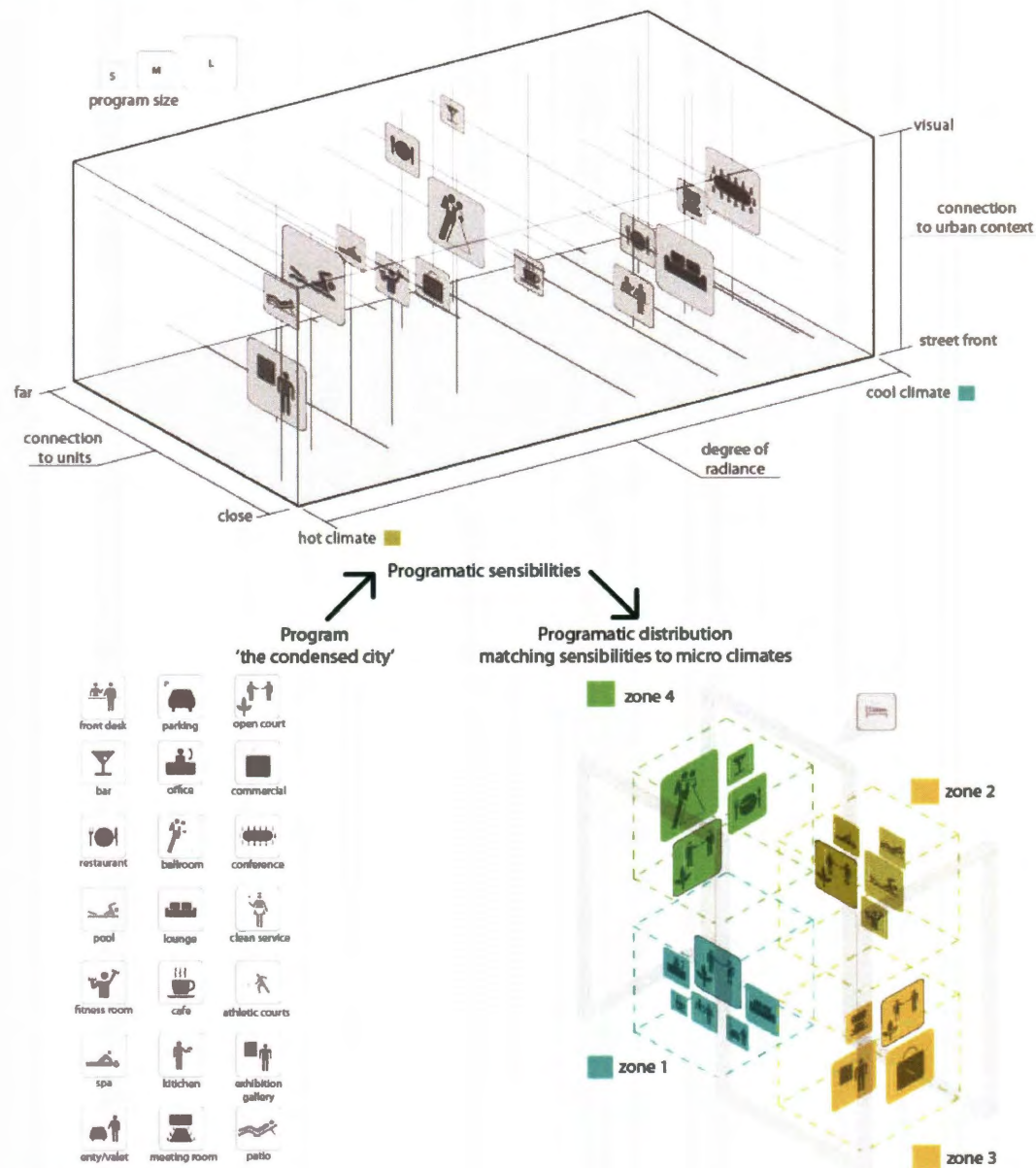


Figure 6.1



## 6.2 - Program distribution

In figure 6.2, each of the public programs can be seen mapped out through the internal core. Each floor plate expands and contracts through small variations based on the formal process. This allows each programmatic element to be located within its required spatial needs - smaller programs such as maid service and storage are located in the narrow floor plates and large programs such as pools and ballrooms are located in the expanded floor plates which occur in each micro-climatic zone.

Also overlaying the internal core is the continuous structural skin, which modulates openings according to solar exposure and structural bracing. This is further explaining in the following chapter.

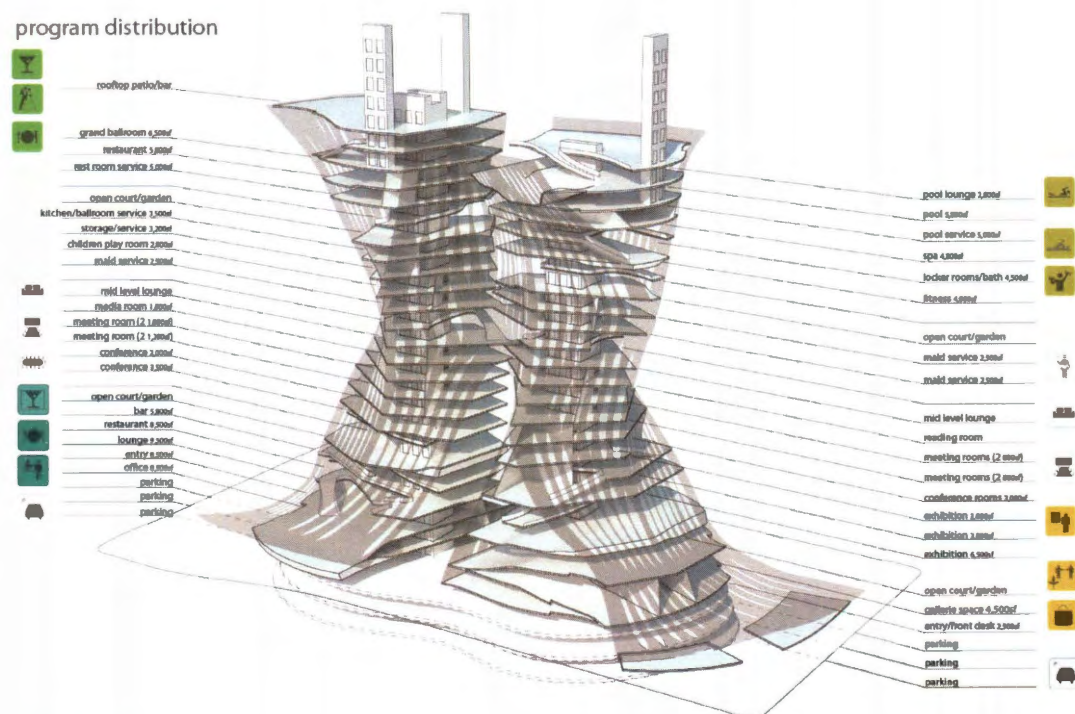


Figure 6.2



## Chapter 7 - Building visualizations

### 7.1 - The building skin

The skin of the building has an integral role in controlling air movements, circulation of people, day lighting exposure and structural support.

This is achieved through layers of skin, the first wrapping the interior core uses a bundling logic to provide openings for daylight, controls the access in and out of the unit corridors and cross bracing for structural support. The interior skin of the units layered with a secondary system that uses ventury stacks to pull

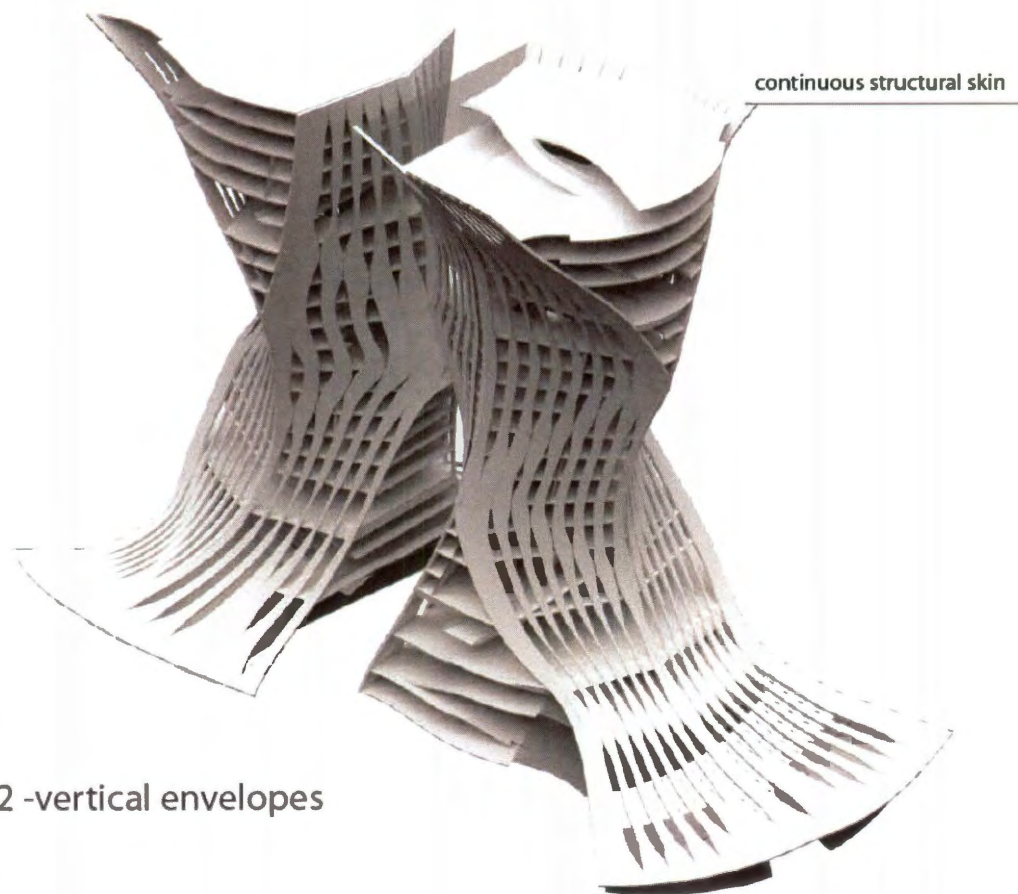


Figure 7.1

air through the units for ventilation. The exterior skin located on the units uses mass customization logic to provide differentiated degrees of shading according to angle of exposure to the sun. A diagonal member separates two pieces of glazing; the top piece angles out to provide shading for the unit, whereas the bottom pieces angles out to provide a vent that is connected to the venture stacks through the common walls of the units.

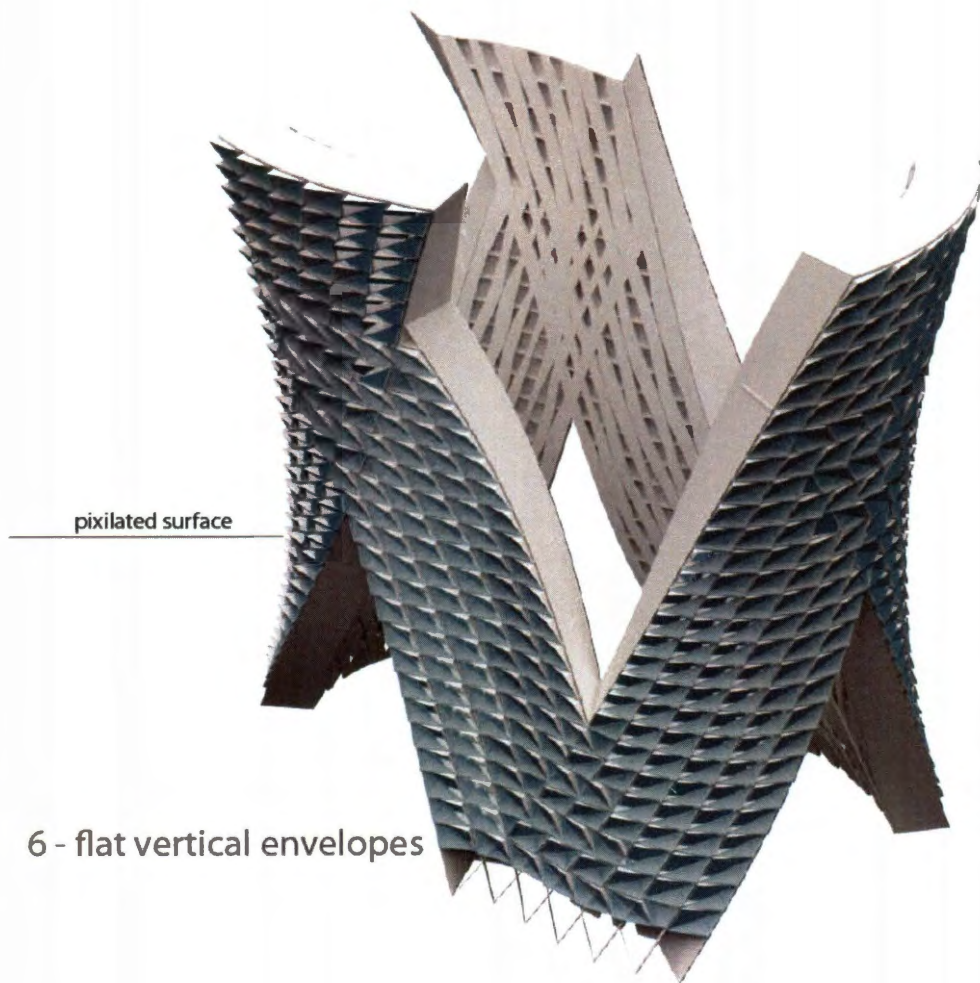


Figure 7.2

The skin of the building has an integral role in controlling air movements, circulation of people, day lighting exposure and structural support. This is achieved through layers of skin, the first wrapping the interior core uses a bundling logic to provide openings for daylight and cross bracing for structural support. The interior skin of the units uses bundling to control access in and out of the unit corridors and is layered with a secondary system that uses venturi stacks to pull air through the units for ventilation. The exterior skin located on the units uses mass customization logic to provide differentiated degrees of shading according to angle of exposure to the sun. A diagonal member separates two pieces of glazing; the top piece angles out to provide shading for the unit, whereas the bottom piece angles out to provide a vent that is connected to the venture stacks through the common walls of the units.

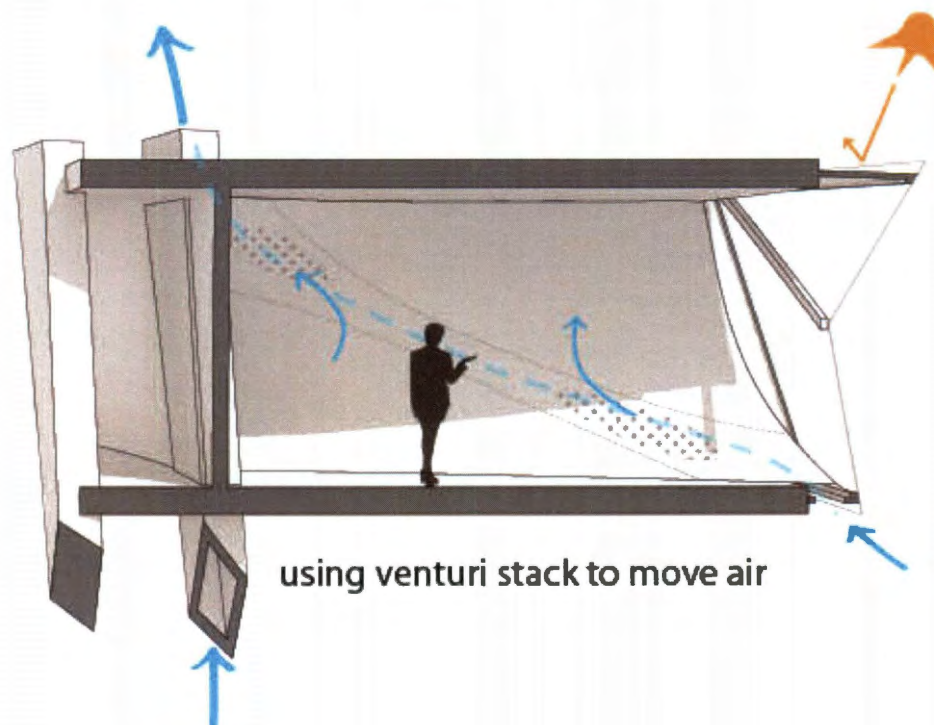


Figure 7.3



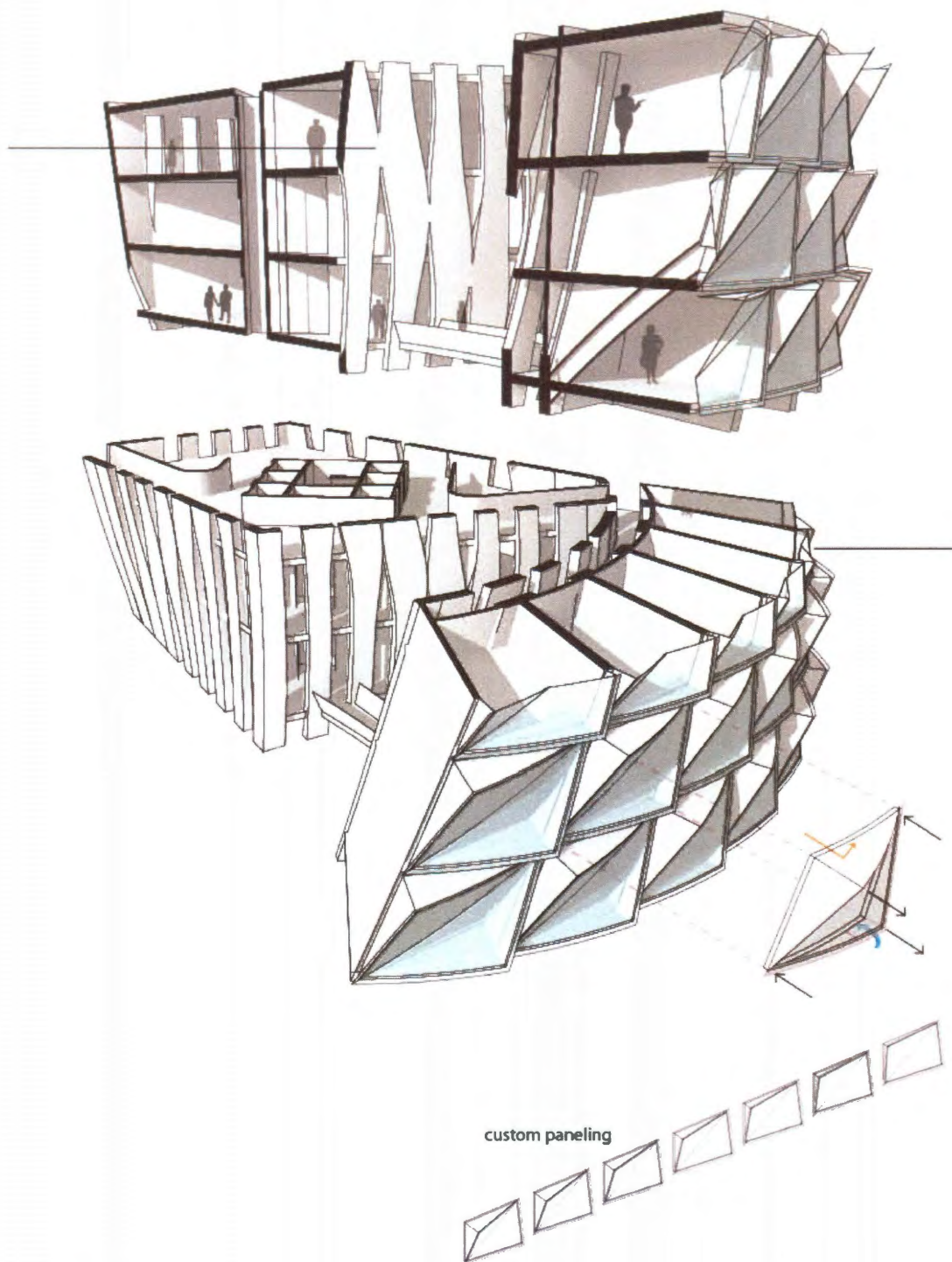


Figure 7.4

## 7.2 - Building sections and perspectives

The 4 micro-climatic zones provide locations for 4 different groupings of collective spaces, the entertainment collective zones holds the grand ballroom and the restaurant based on late afternoon sun exposure and views of the city; the relaxed collective zone holds the lounge, entry and front desk based on low degree of sun exposure and access to the adjacent park

Four open air gardens are centrally located in each zone as a gathering point in each zone and provide spaces that fully engage in the different climates as these spaces are not enclosed.

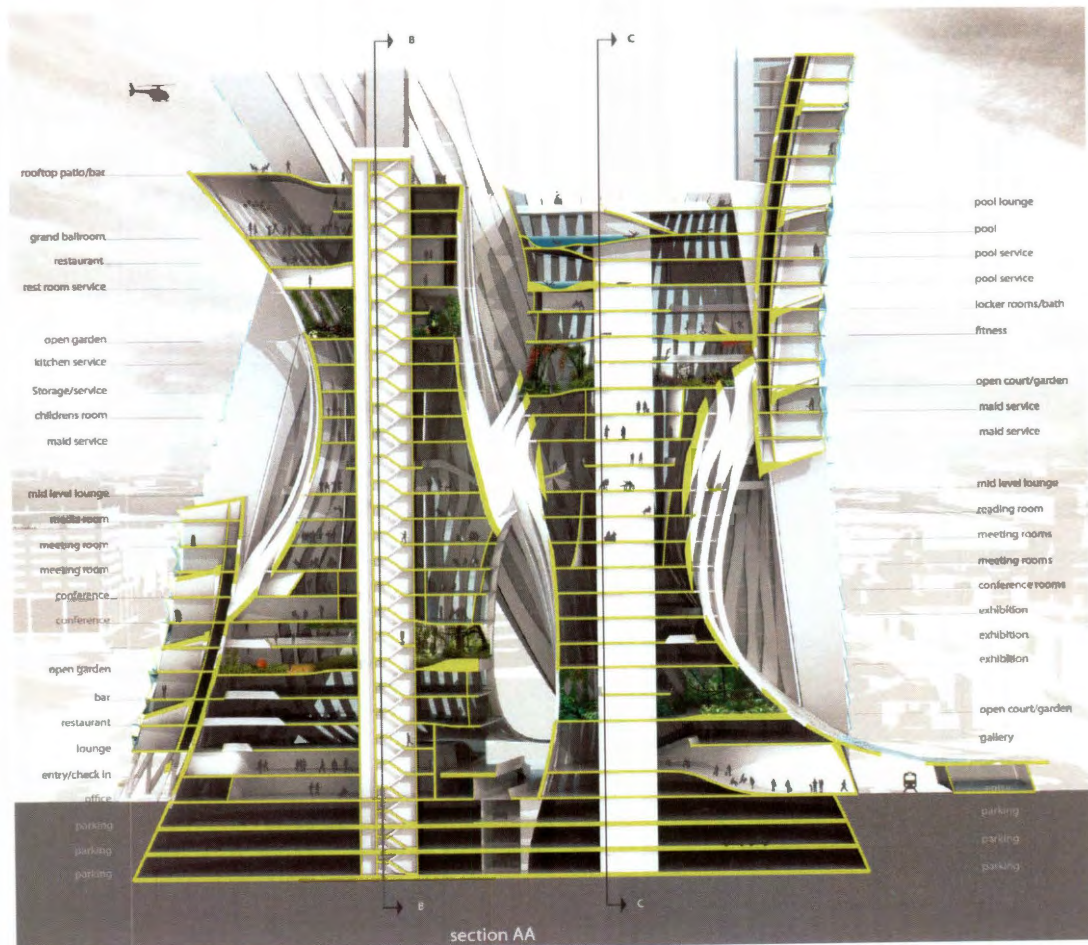


Figure 7.5



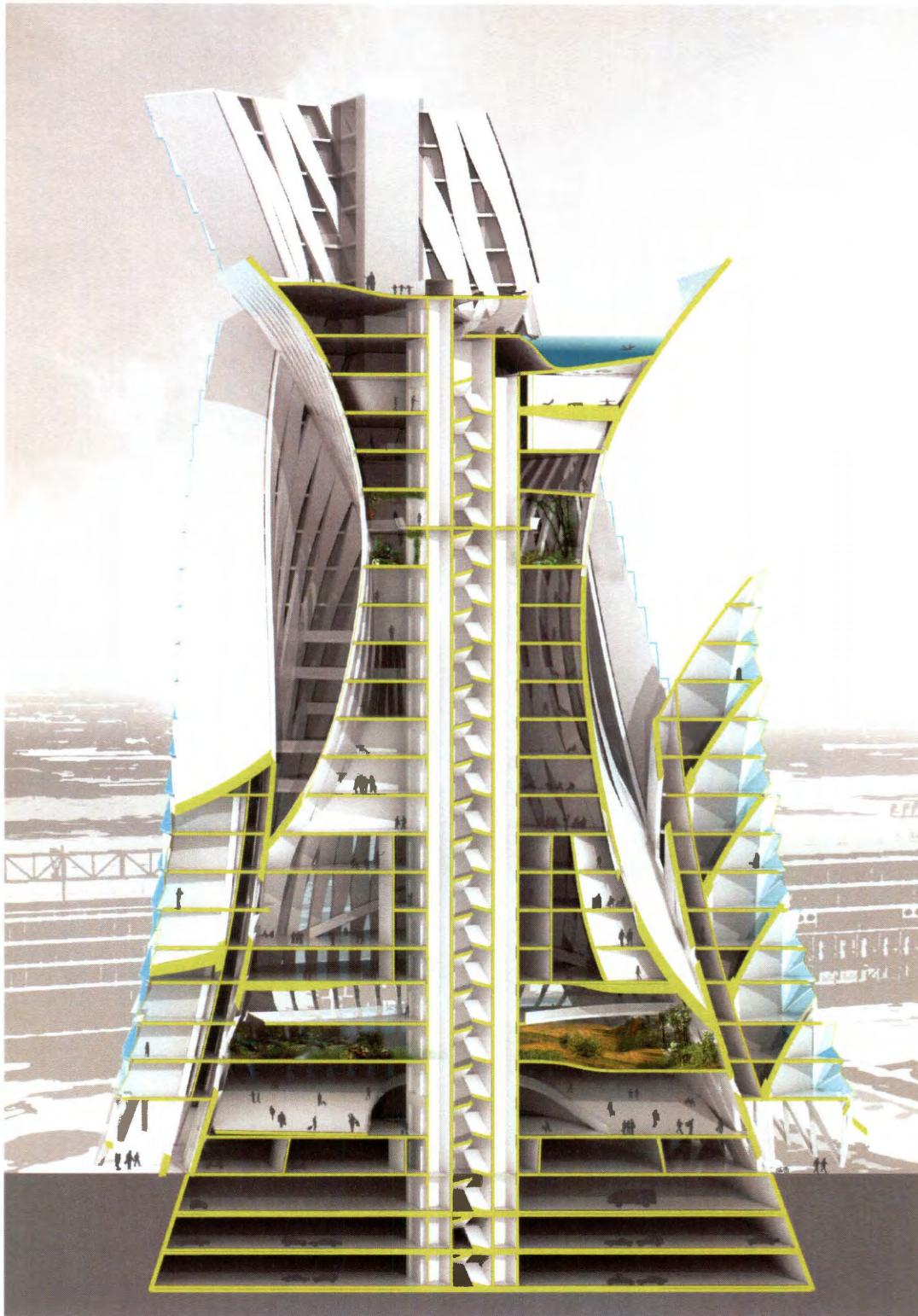


Figure 7.8



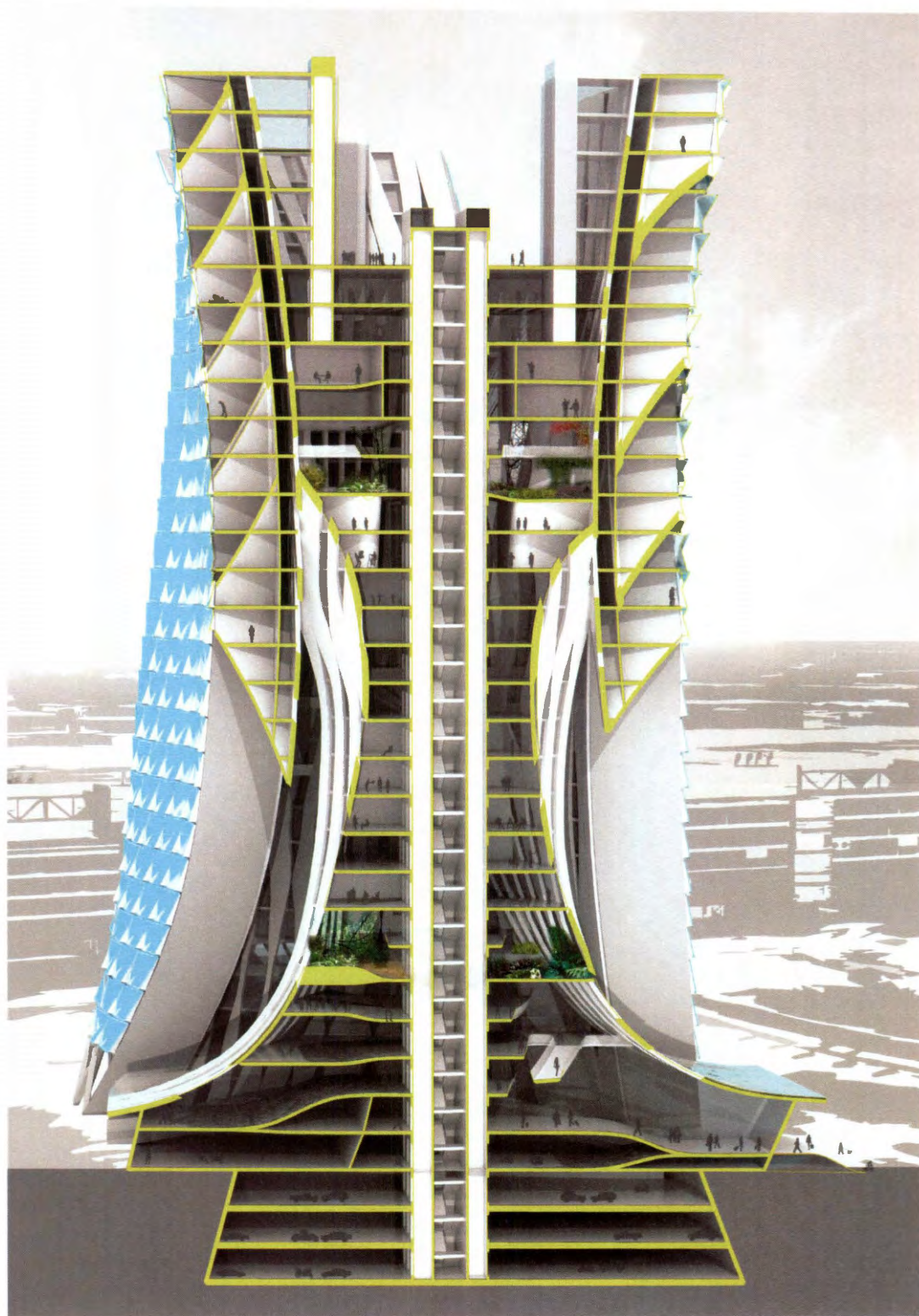


Figure 7.9



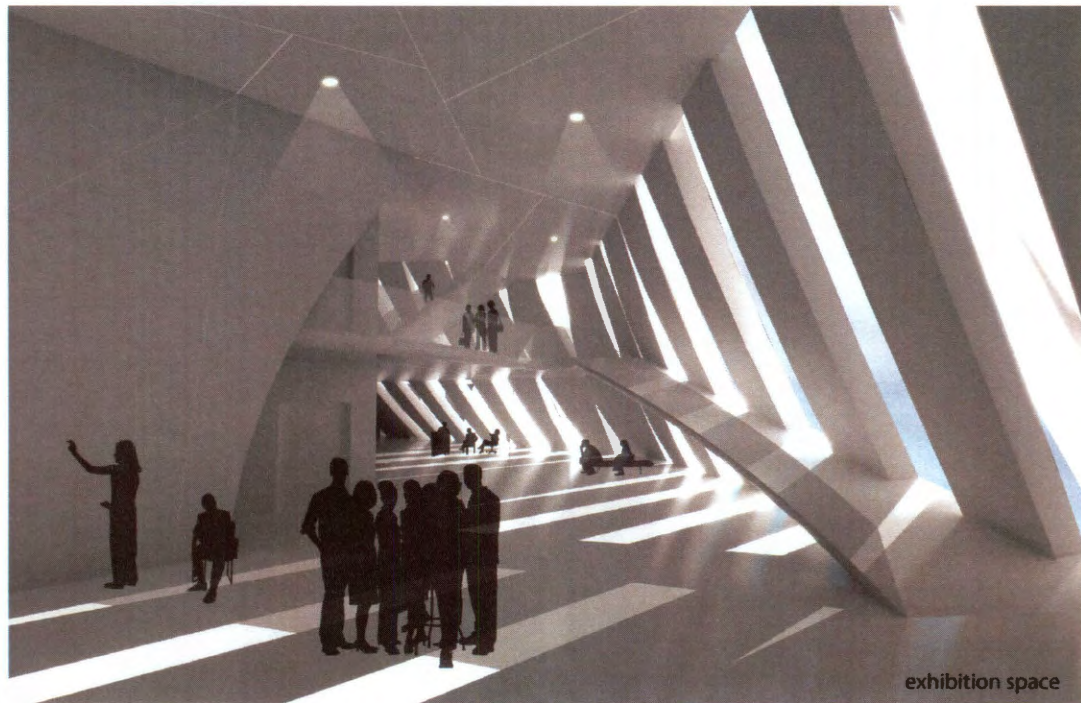


Figure 7.10



Figure 7.11



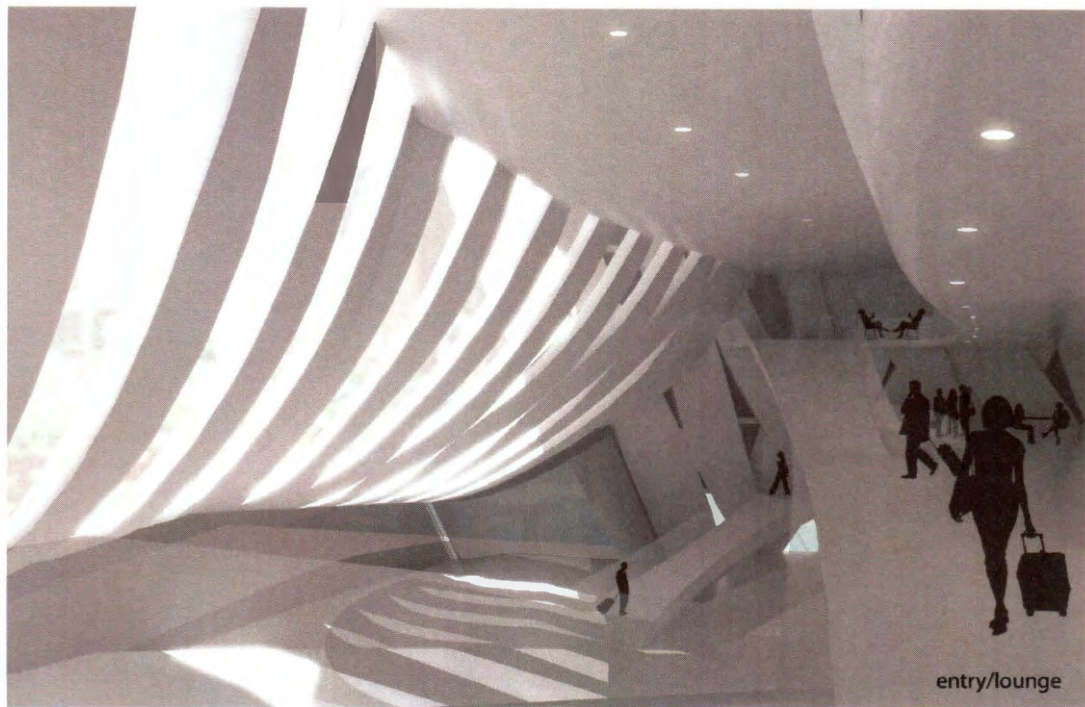


Figure 7.12

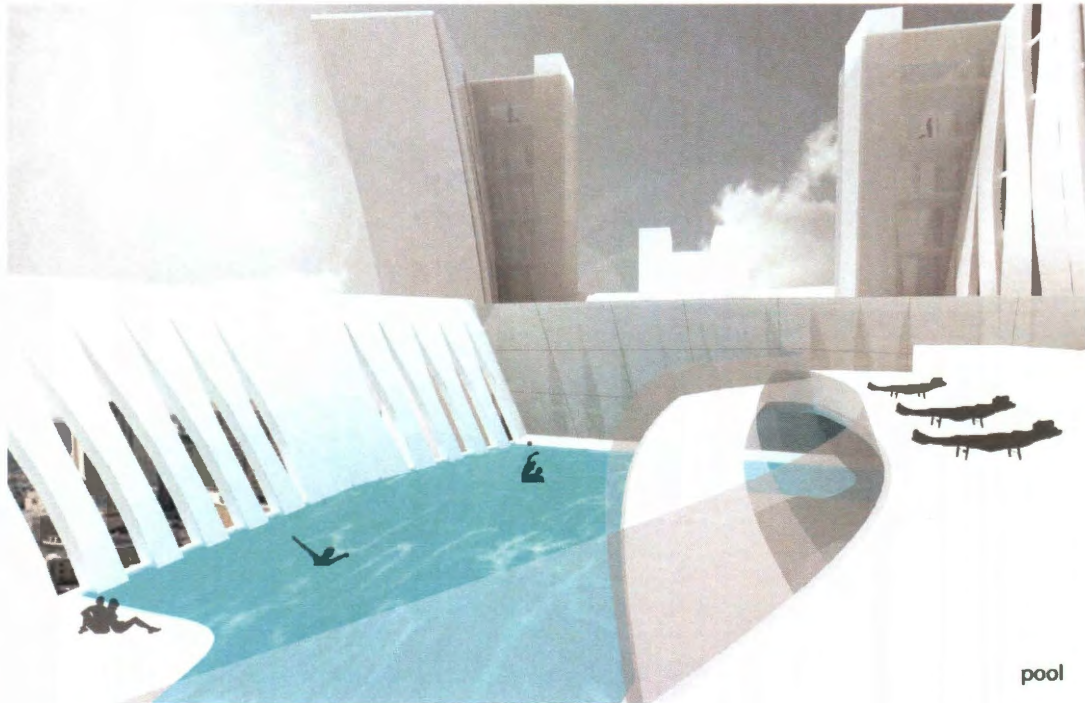


Figure 7.13





Figure 7.14



Figure 7.15

### 7.3 - Building floor plans

These three floor plans show different conditions produced by the two envelope typologies:

- 1 -The top floor plan shows the condition where large public spaces fill the interior core such that the units open out onto these spaces
- 2 - The middle floor plan shows the opposite condition such that the two envelopes are disconnected from one another. Bridges are located within these floor plates and pass through the openings in the skin to provide access to the units.
- 3 -The bottom floor plan shows an open air garden and the accessibility from the core elevators to the units.

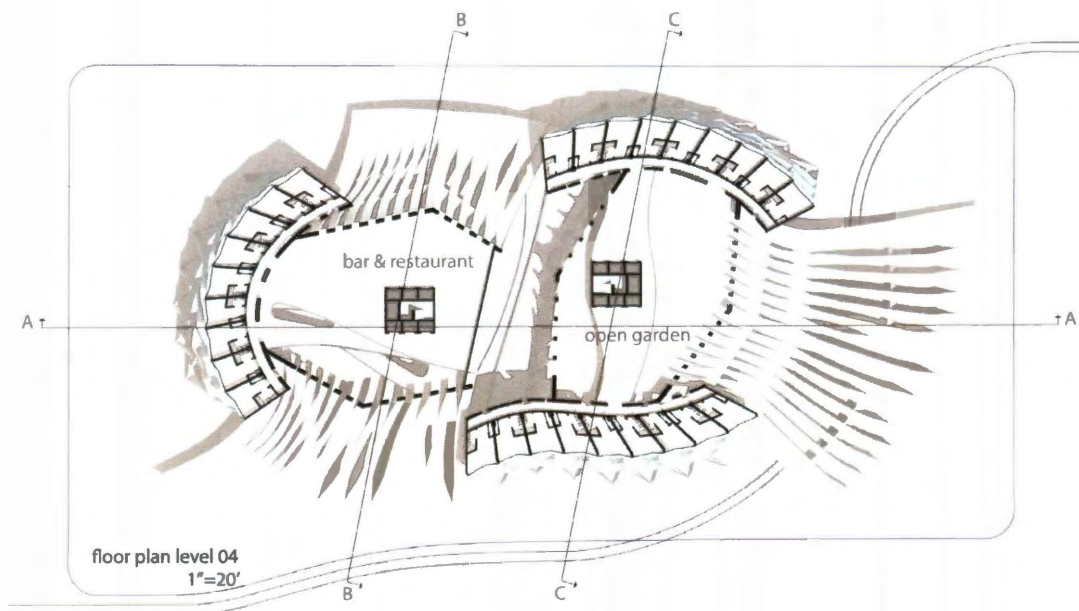


Figure 7.16



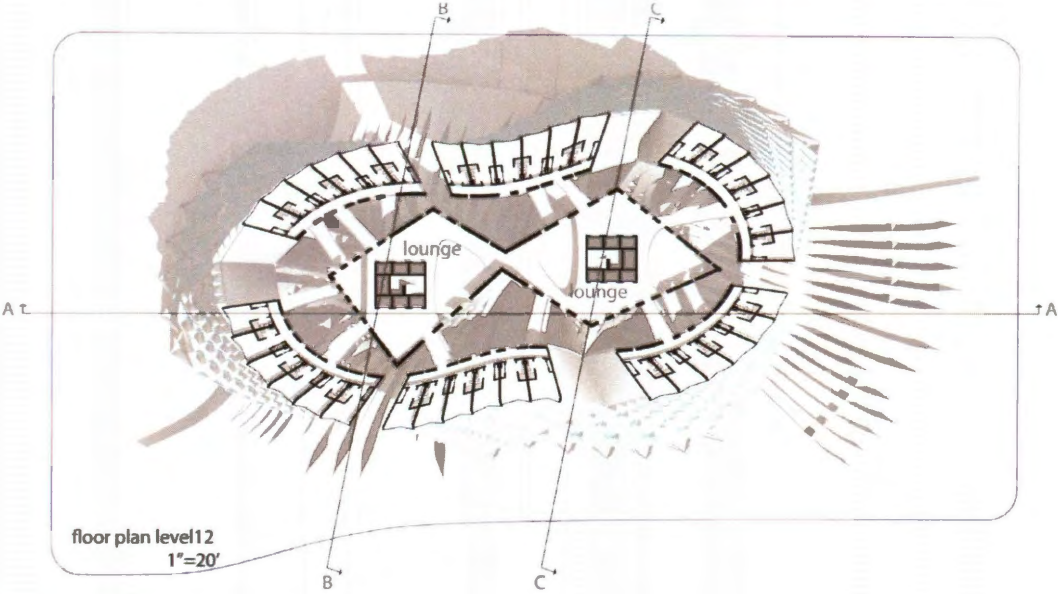


Figure 7.17

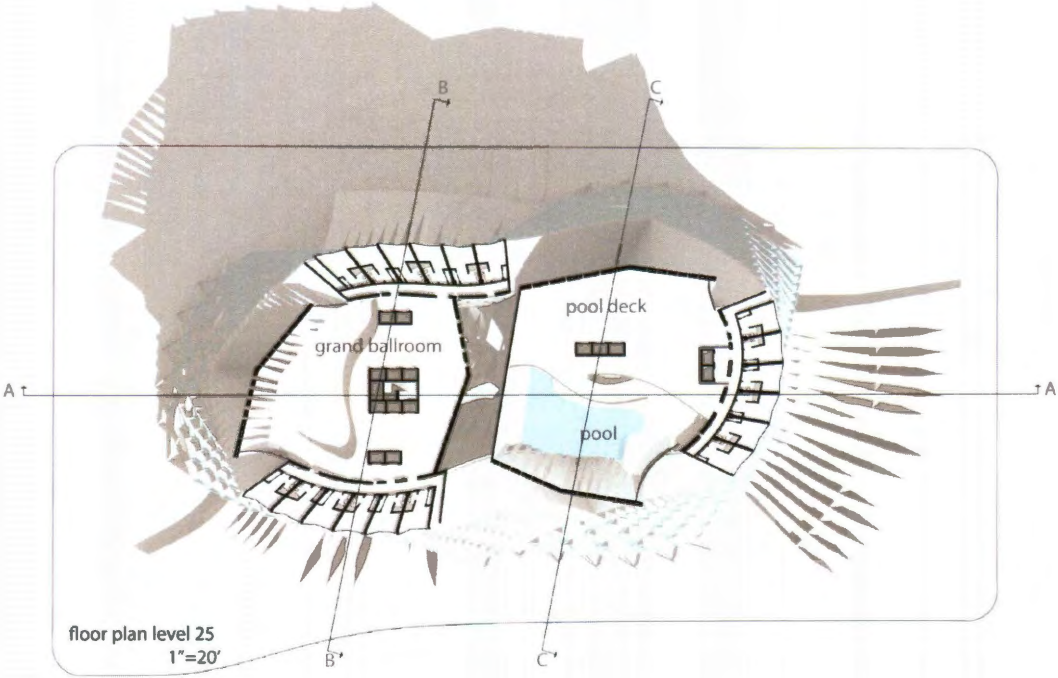


Figure 7.18

## Chapter 8 - Conclusion

With the continuous growth of our cities and the growing concern over global climate, we are forever evolving away from traditional trends to more sophisticated and environmentally responsive architecture. In many cases this has resulted in two paths: one that praises performative efficiency but reducing our collective space into a homogenize environment or another that creates a radical figure that trades in efficiency to meet the dynamic needs of the collective subject. This thesis concludes that future trends can utilise the technology and knowledge of both the mentioned paths to create a synergetic relationship that does not hide form environmental forces but rather embraces them to create a more dynamic environment for our collective spaces.

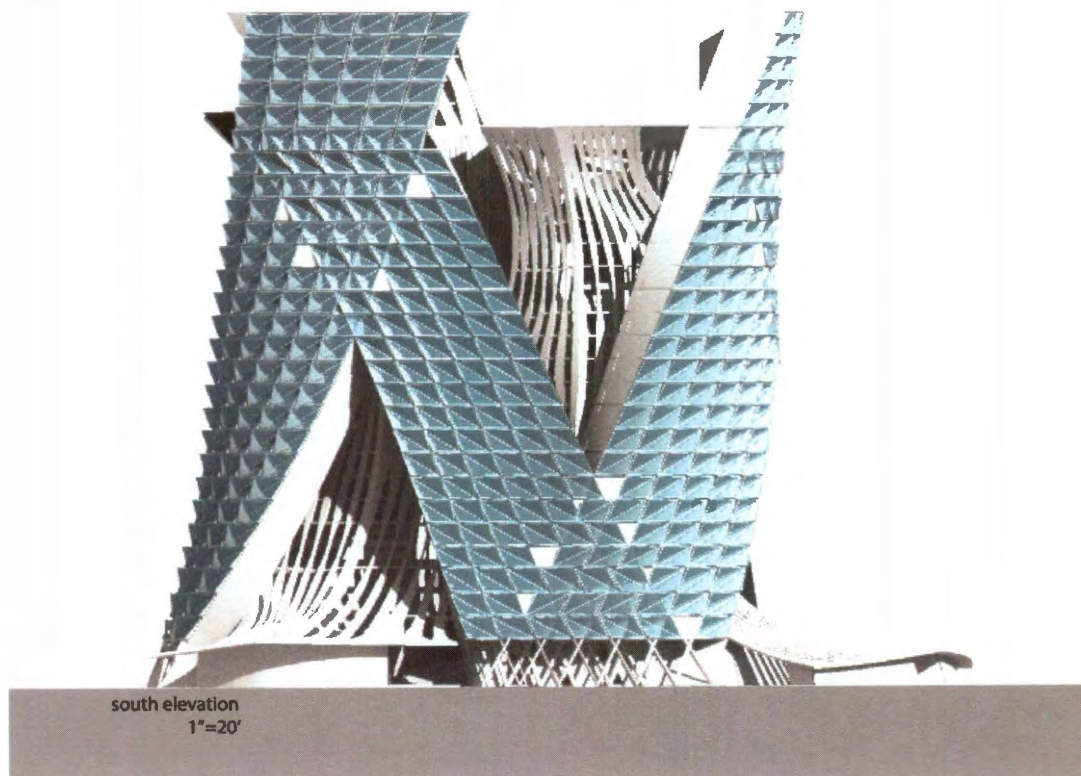
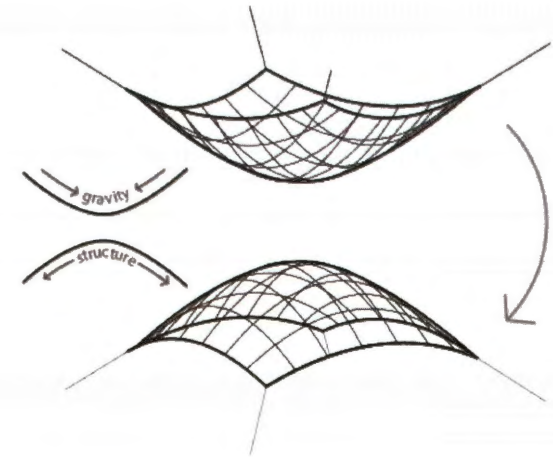
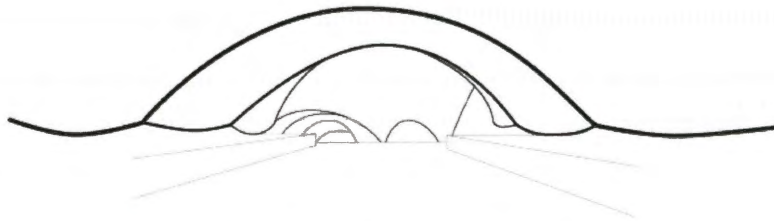


Figure 8.1





#### Intrinsic nature of structural loads

Over recent history architects such as Frei Otto developed a method known as 'form-finding' to establish structural form in response to external stimuli. This method is based on utilizing the selforganisational characteristics of materials and material systems in response to extrinsic influences. Antoni Gaudi used this method to 'form-find' the catenary arches of the Guell church in an additive quasi bottom-up manner, while Frei Otto mostly utilised the method to establish the overall form of gridshells, membrane roofs and so on, whether these were used in an additive manner or not. What is striking, however, is that this method has not been developed subsequently to incorporate an increasing number of variables. There is therefore great potential in the formfinding approach that has its correspondences in the pattern formation in many natural systems, whether non-living or living.

PROJECT  
Multihalle Mannheim

PROGRAM  
Public

ARCHITECT  
Frei Otto

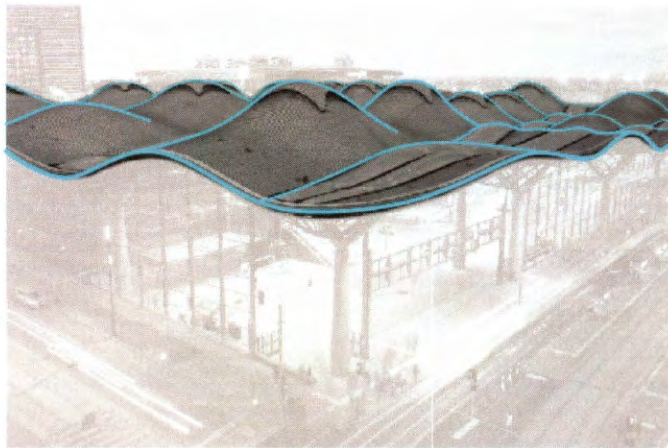
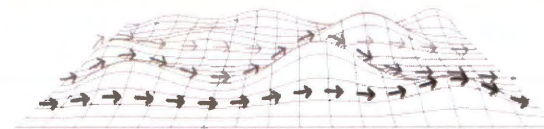
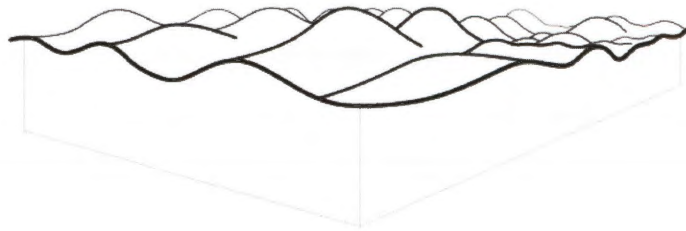
LOCATION / DATE  
Melbourne, Au

NATURAL SYSTEM  
Intrinsic Nature of Structural Loads

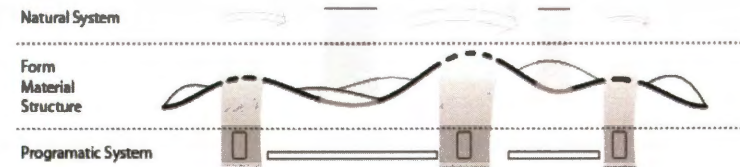
PERFORMATIVITY  
Space Inclosure



Case Study 01



The focus of the station is the dune-like roof that covers an entire city block: it works as a visual bridge between the city center and the new docklands. The form has been generated by the need to extract the diesel gasses and provide cooling via natural ventilation. The form/structure/material performs as a mediator between the programmatic systems and the natural systems.



PROJECT  
Southern Cross Station

PROGRAM  
Train Station

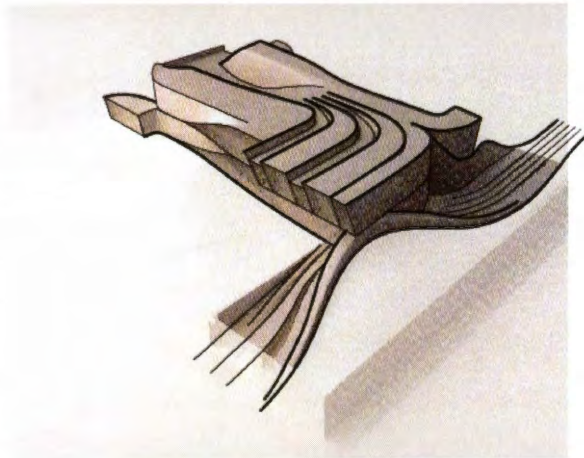
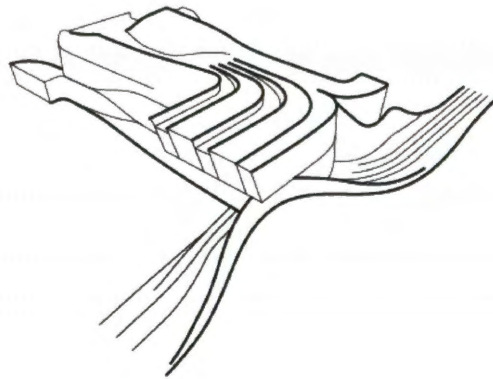
ARCHITECT  
Grimshaw

LOCATION / DATE  
Melbourne, Au

NATURAL SYSTEM  
Natural Wind Flow and Light

PERFORMATIVITY  
Passive Air Circulation Through Differnt Pressures

Case Study 01



"Pressure Points" and  
Flow of Program



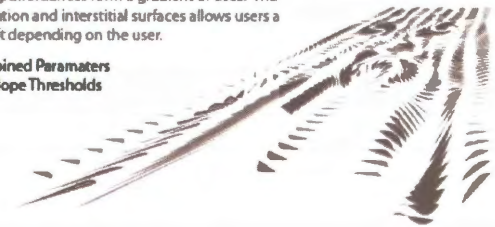
Natural Rate of  
Change on Site



The project uses temporal techniques - specifically a dynamical system model that allowed the creation of continuous interchange between building and landscape along with three differentiated channels, that generated affordances that change depending on the season. The shifting/affordances form a gradient of uses. The combination of these speeds of circulation and interstitial surfaces allows users a range of possible occupations that shift depending on the user.



Combined Parameters  
Develop Thresholds



PROJECT  
Variations

PROGRAM  
Residence

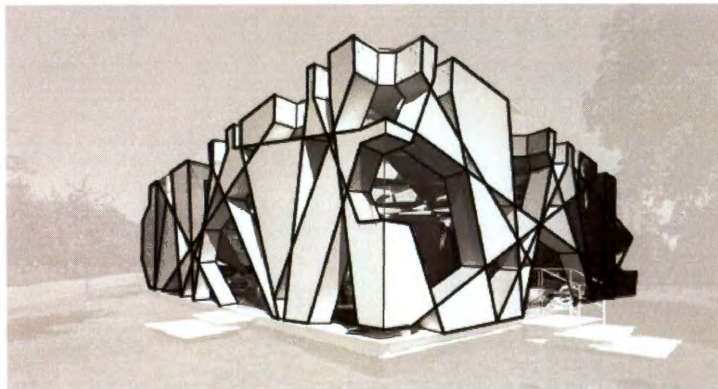
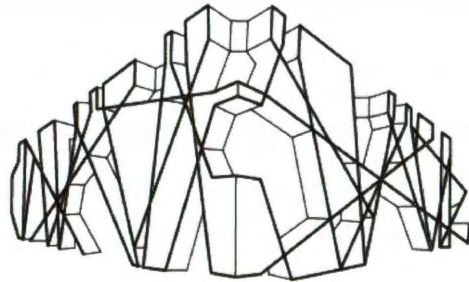
ARCHITECT  
Ali Rahim

LOCATION / DATE  
London, UK

NATURAL SYSTEM  
Temporal Techniques/Virtual Flow

PERFORMATIVITY  
Range of Occupations for Surfaces

Case Study 01



PROJECT  
Serpentine Gallery

PROGRAM  
Pavilion

ARCHITECT  
Toyo Ito

LOCATION / DATE  
London, UK

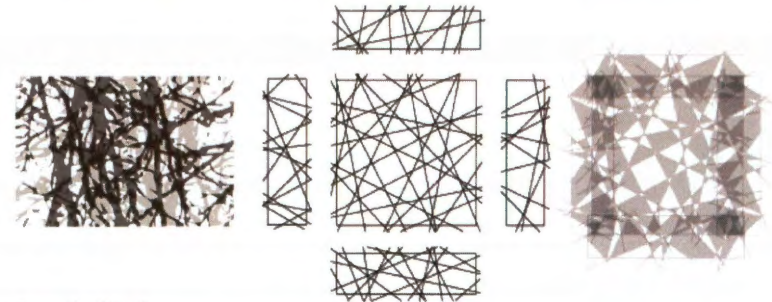
NATURAL SYSTEM  
Random and Gradient Patterns

PERFORMATIVITY  
Random Affect Emerging a Field of Possibilities

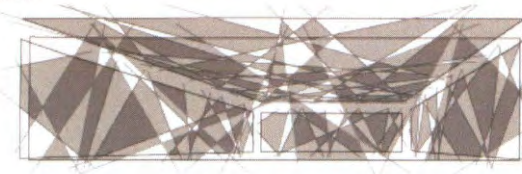
Natural Affect of  
"Randomness and Gradient"

Pattern Strategy and  
Structural Components

Overlapping of Elements  
Produce Gradient



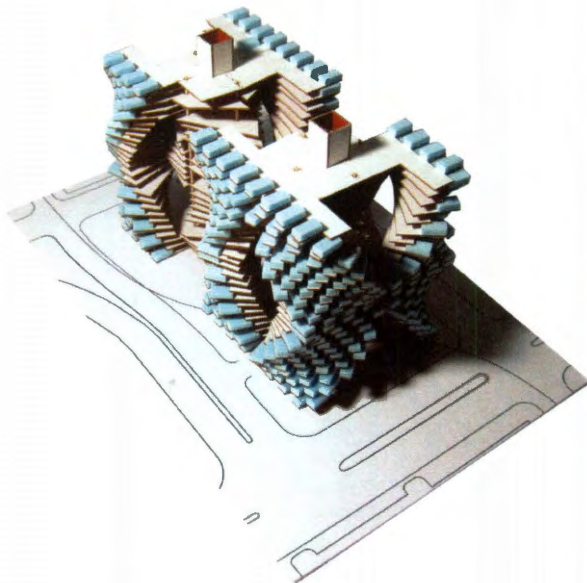
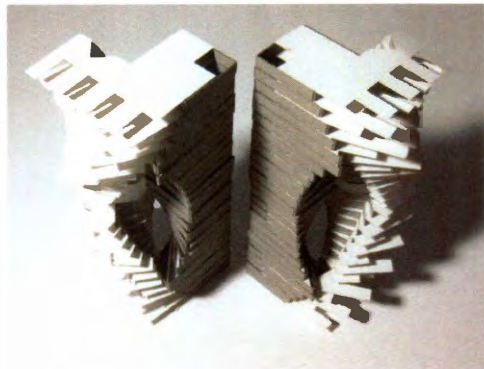
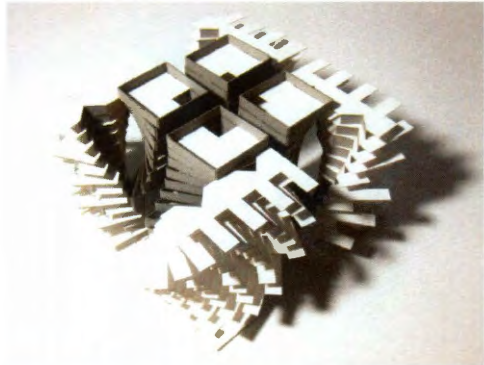
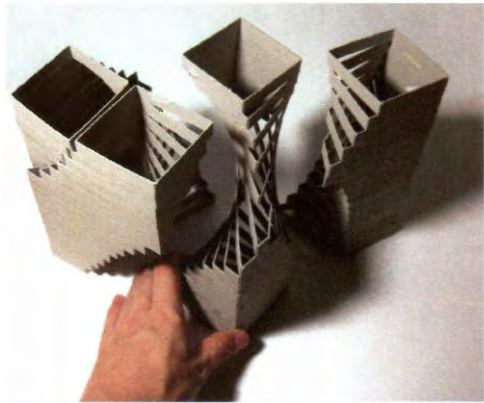
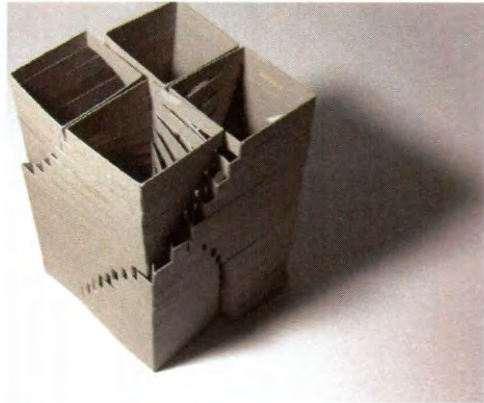
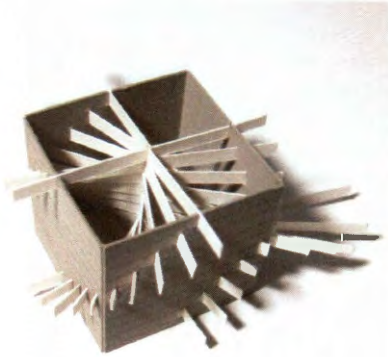
Perspective View of  
Overlapping Elements



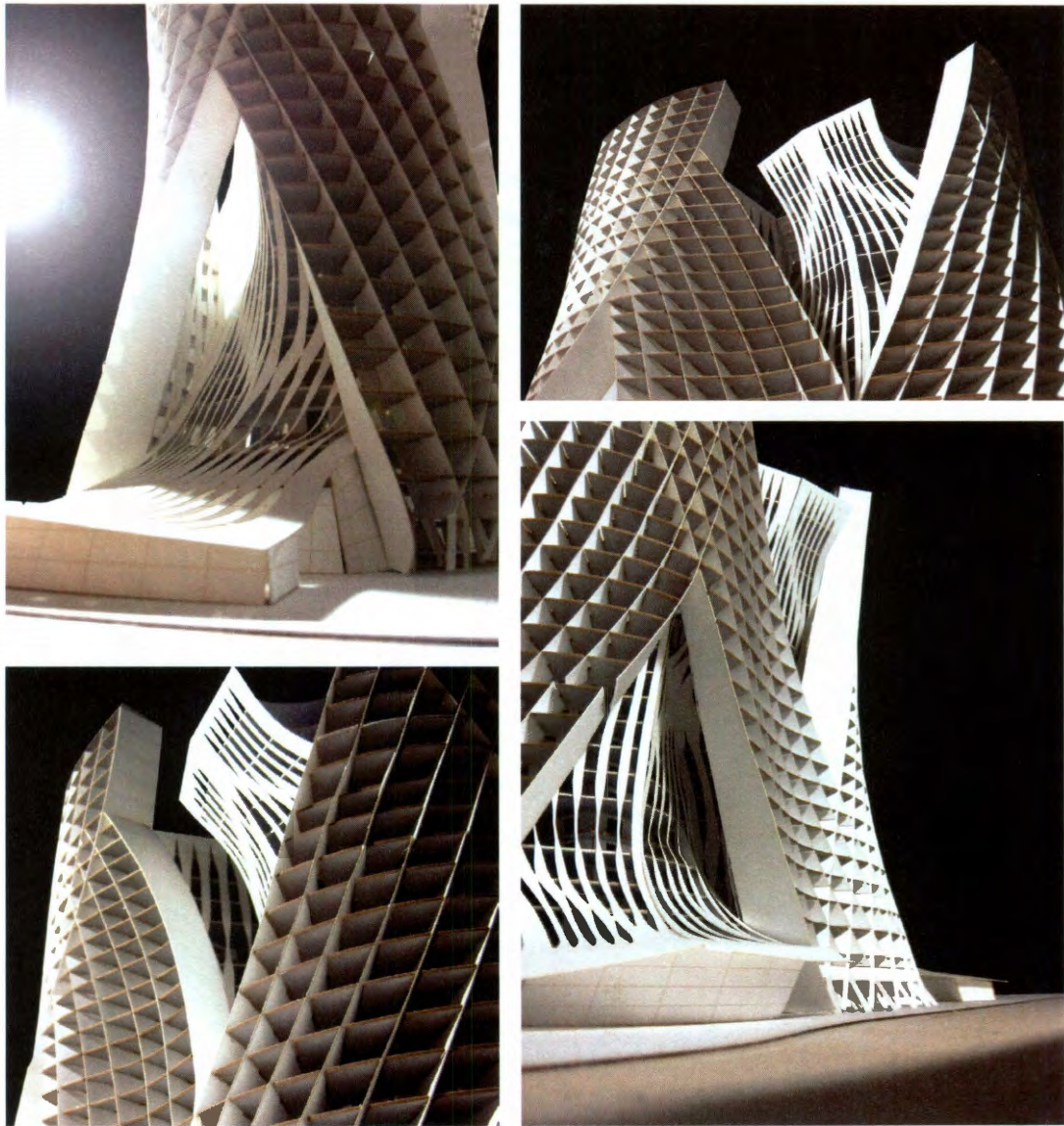
The serpentine Pavilion creates a random affect through a patterning investigation enabled by structure. An irregular pattern, generated by an algorithm that rotates and scales the extended lines of a square, is cropped to produce a seemingly random pattern through a regular process





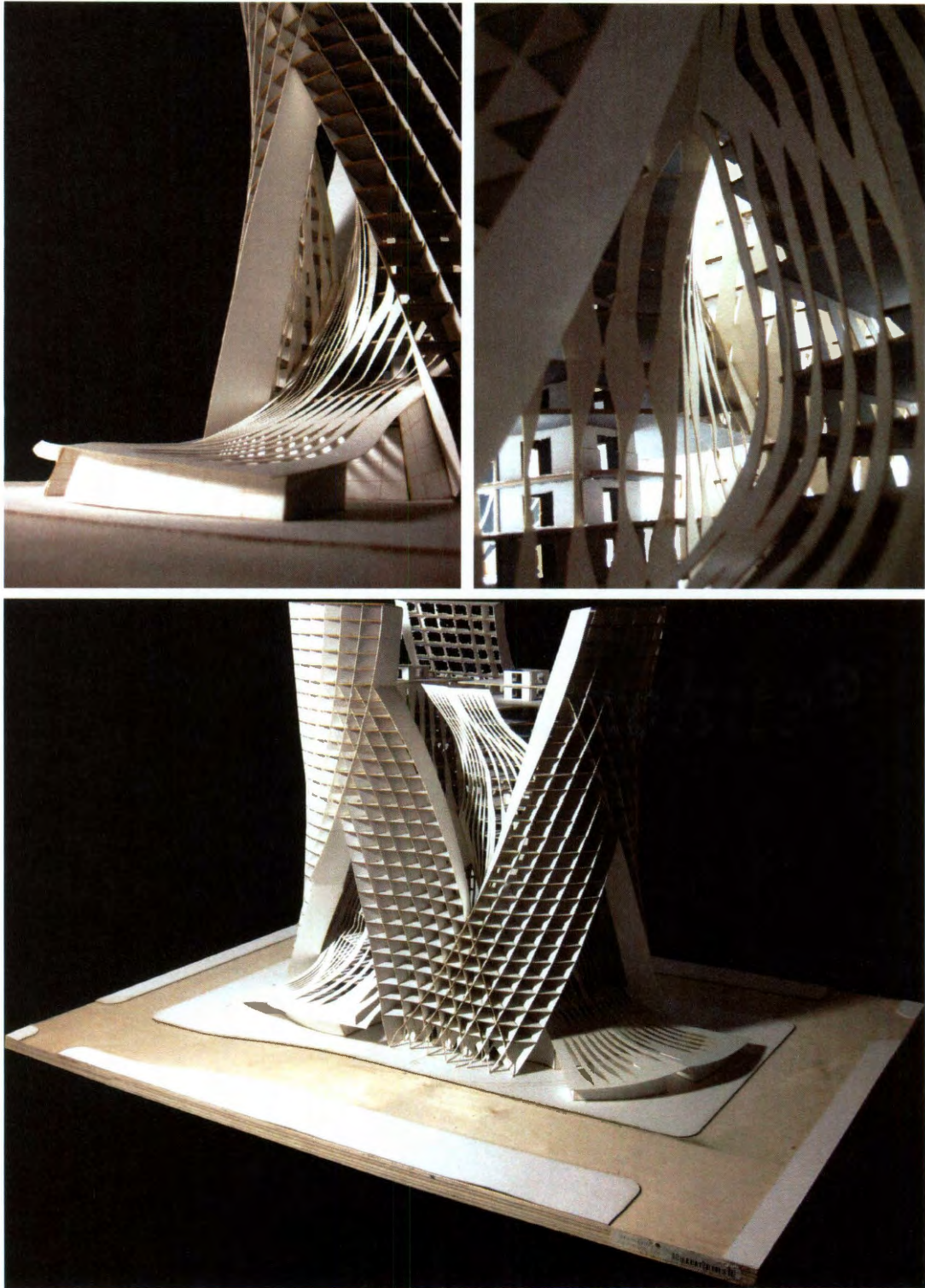


Study Models



Final Model





Final Model

## REFERENCES

- Agkathidis, Asterios. *Modular Structures in Design and Architecture*. Amsterdam: Bispublishers, 2009. Print.
- Andersen, Paul, and David L. Salomon. *The Architecture of Patterns*. New York: W.W. Norton &, 2010. Print.
- Aranda, Benjamin, Chris Lasch, Cecil Balmond, and Sanford Kwinter. *Tooling*. New York: Princeton Architectural, 2006. Print.
- Banham, Reyner. *The Architecture of the Well-tempered Environment*. Chicago: University of Chicago, 1984. Print.
- Hensel, Michael, Achim Menges, and Christopher Hight. *Space Reader: Heterogeneous Space in Architecture*. Chichester, U.K.: Wiley, 2009. Print.
- Hensel, Michael, Achim Menges, and Michael Weinstock. *Emergent Technologies and Design: towards a Biological Paradigm for Architecture*. Oxon [England: Routledge, 2010. Print.
- Hensel, Michael, and Achim Menges. *Morpho-ecologies*. London: Architectural Association, 2006. Print.
- Hensel, Michael, Achim Menges, and Michael Weinstock. *Techniques and Technologies in Morphogenetic Design*. London: Wiley-Academy, 2006. Print.
- Hensel, Michael, and Achim Menges. *Versatility and Vicissitude: Performance in Morpho-ecological Design*. London: Wiley, 2008. Print.
- Kolarevic, Branko, and Ali M. Malkawi. *Performative Architecture: beyond Instrumentality*. New York: Spon, 2005. Print.
- Nerdinger, Winfried, and Frei Otto. Frei Otto, *Complete Works: Lightweight Construction Natural Design*. Basel: Birkhäuser, 2009. Print.
- Rahim, Ali. *Catalytic Formations: Architecture and Digital Design*. London: Taylor & Francis, 2006. Print.
- Spuybroek, Lars. *Research & Design: the Architecture of Variation*. New York: Thames & Hudson, 2009. Print.
- Weinstock, Michael, Achim Menges, and Michael Hensel. *Emergence Morphogenetic Design Strategies*. Chichester: Wiley-Academy, 2004. Print.